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COVER
An artist's conception of the "city with sea legs," now being designed under the leadership of Dr. John P. Craven of the University of Hawaii, with partial support from NOAA's Office of Sea Grant.

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Constructive Guilt— An Environmental Phenomenon

DR. WILLIAM ARON
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ECOLOGY AND ENVIRONMENTAL
CONSERVATION

Imported with the Pilgrims and passed unrelentingly through the centuries, the guilt complex is an enduring part of American life, a Puritan legacy which defies time, tide and fashion.

Americans are uneasy unless they have something to feel guilty about. From earliest childhood to the brink of the grave, guilt pursues us ruthlessly. And it is by no means confined to our personal lives; a pervasive sense of guilt often nags us about those things being done, or not being done, by others—all the way from our neighborhoods to the highest councils of government. This is highly frustrating, because we tend to feel that we can do nothing, or at best very little, about the things that offend us; and even then we are frequently unsure about just what *should* be done.

Our newest national guilt complex can only be described as a lulu, holding the seeds of consequences not only for ourselves and those we love, but future generations for which we hold our planet in stewardship.

It is nothing less than environmental guilt, on a scale so grand as to delight the most jaded psychiatrist. It appears to strike most severely those not in a position to inflict or prevent environmental despoilment—in other words, those who feel they can do little or nothing about it.

However, as sometimes happens, the gnawing consciousness of millions of persons who by themselves can accomplish little has developed into a mass environmental conscience, one which is being heard and which can move the world. It is, indeed, one of those rare triumphs of the individual facing a system too big to handle alone.

We are guilty about our environment because there is chilling evidence that we may be almost literally consuming it; what we are feeling is essentially the foreboding a well-bred Yankee banker would feel about dipping into capital.

We expect a great deal of our environment, we Americans. We want every environmentally-damaging comfort and convenience—and we want clean water, pure air, wild rivers, wilderness areas, flourishing marine, bird and animal life, and much more. We are at a most uncomfortable crossroads.

Opinion swings wildly between the extremes when we are faced with hard environmental decisions. Some would make Earth a great preserve, at the expense of the most basic advances earned for us by our technology. Others would plunder our natural resources and leave the consequences to a future which is approaching with great rapidity.

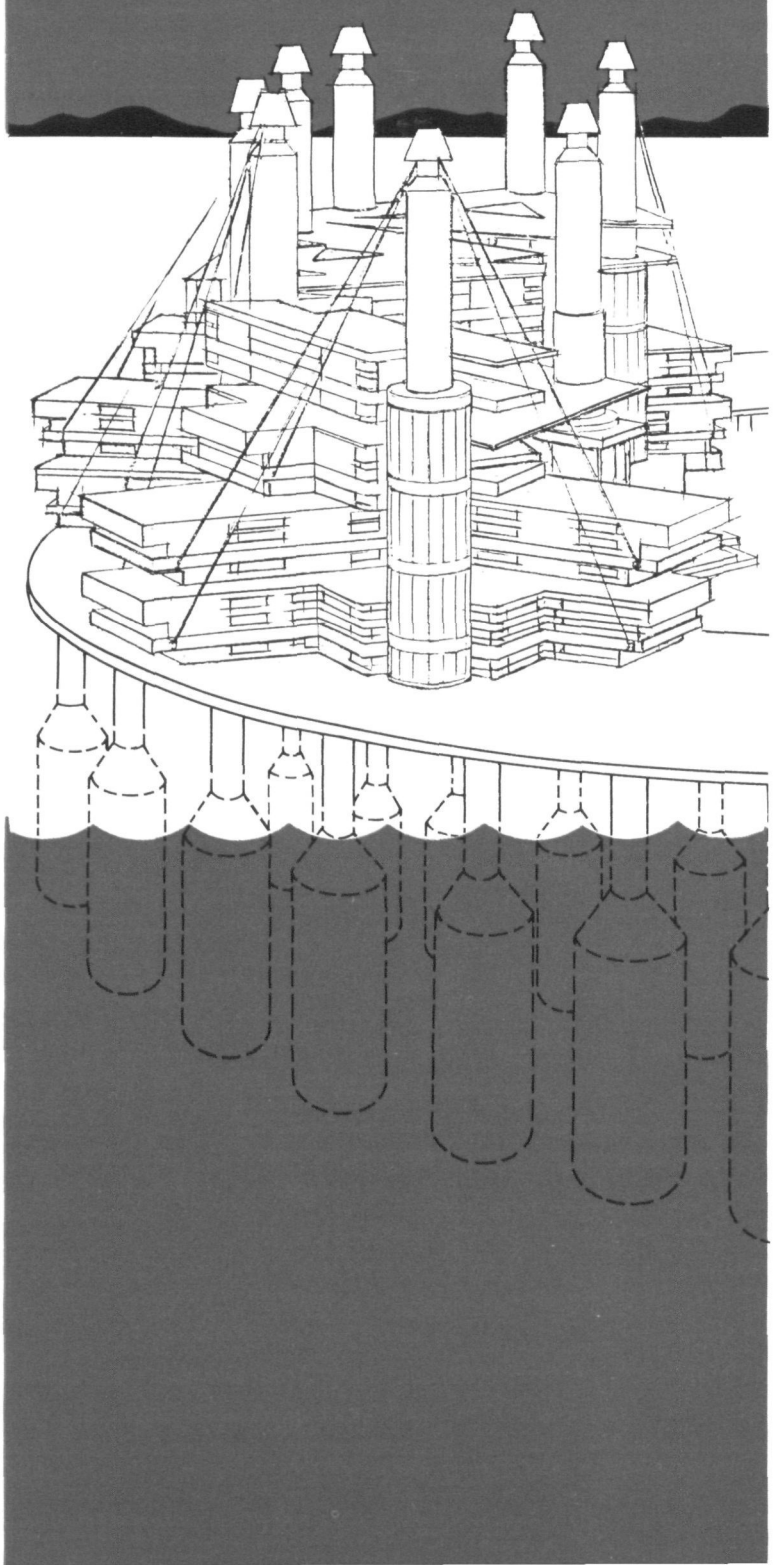
I believe we can enjoy a high standard of living, make commercial and industrial progress, develop our coastal zones, and with all of this not only sustain but improve the quality of our environment.

It can be done, however, only by acting with restraint, by judging the consequences of our actions on a long-term basis, and by attaining considerably more information and better interpretation of environmental processes than we now possess. This means that we must give a high priority to the solution of our environmental problems, including long-range efforts without immediate or spectacular payoff.

Meanwhile, our new environmental conscience is a weapon as mighty as our scientific and technological abilities. If this is guilt, it is constructive guilt, and the Puritans would have been proud of us.

A CITY WITH SEA LEGS

An "Atlantis in the Pacific" is no joking matter at the University of Hawaii where they're planning . . .



Before the Nation's two hundredth birthday celebration in 1976, or shortly thereafter, an island city floating on hollow legs of reinforced concrete could rise from the ocean three miles out from Honolulu. Fantastic? Maybe, but certainly within the realm of possibility, for even now a determined group of scientists, engineers, businessmen, students and state legislators are deep in the midst of plans for the world's first floating city.

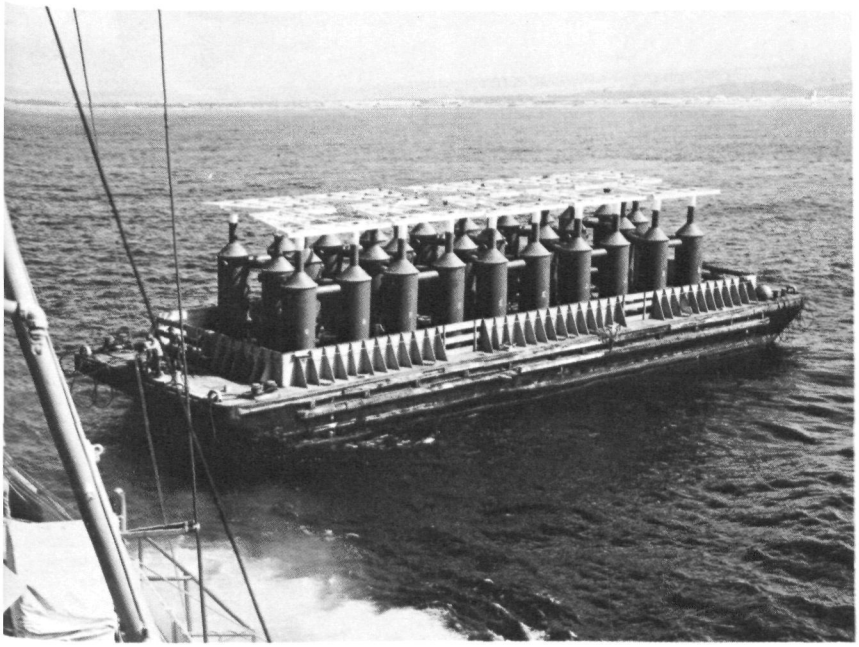
The man behind this "Atlantis in the Pacific" is John P. Craven, dean of marine programs at the University of Hawaii and marine coordinator for Governor John A. Burns. He has been asked to come up with plans for an international exposition that will span two celebrations—the 1976 bicentennial of the Declaration of Independence and the 1978 bicentennial of the Hawaiian Islands, discovered by Captain James Cook. Dr. Craven believes the exposition could be set up on a huge floating platform—a self-contained city at sea linked to the mainland by high speed water transportation. Here, in a single project, Dr. Craven envisions not only a tremendous tourist attraction and fitting tribute to progress in the marine sciences on the island state, but also the prototype of a solution to planetary overcrowding—the opening of the oceans (70 percent of the earth's surface area) to new settlement.

Here's what he proposes:

The city's surface structure would be built on a ring of wedge-shaped modules circling a central harbor. The area of each module would be about a city block and Dr. Craven would like to see a minimum of ten modules for this first island city. A monorail might circle the inner city and still more modules built on the track's outer perimeter to allow more living and working space. Except for commercial services, the general rule would be pedestrian traffic only. Upper-level structures would be reserved for living and recreation, lower levels for support services.

The city's sea legs consist of large perpendicular cylinders—three to a module—partly above and partly below the water. The legs provide stability as well as support for the module, which is suspended between them. The underwater portion of these legs would extend down 200 feet. The underwater diameter of each cylinder would be 80 feet. This draft would place most of the

BY CHARLES G. THOMAS



(Left) Scale models of the wedge-shaped modules for a floating city are taken to sea for testing. (Right) The modules form a ring with a central harbor.

structure's mass below the influence of surface waves. Near and above the surface, the legs would narrow to 27 feet so that surface waves would be essentially undisturbed, preventing their battering effect on the structure. The ballast of each leg could be controlled individually and, in fact could provide housing for the community's power plant, garbage and sewage treatment plant, fuel and water storage.

Transportation to and from the mainland would be by container barges, high-speed hydrofoil craft and other waterborne transport. The city might have a heliport.

The proposed floating community had its legislative beginning in 1970 when the state's lawmakers enacted a bill calling for a marine exposition to be held in 1976. Dr. Craven, as marine affairs coordinator for the state, was authorized to investigate ways a meaningful exposition could be brought about. The initial investigation concentrated on the relationship between Hawaii and its marine environment and drew heavily on the Governor's Task Force Report, "Hawaii and the Sea," published in 1969, as an expansion of the report on the present and future of "Our Nation and the Sea," by the Commission on Marine Science, Engineering and Resources.

Suggestions solicited from business and community leaders developed the idea of relating the marine exposition to the national bicentennial and to the Hawaiian bicentennial. It was decided to combine the two into a single "celebration" spanning the period of July 4, 1976 to January 13, 1978 (the date of discovery). The exposition was to concentrate on a demonstration of the use of the marine environment for the future societies of men. John Craven's floating city idea seemed a natural.

In the spring of 1971, a preliminary study of such communities was begun by the University of Hawaii, the Oceanic Foundation, and the U.S. Navy's Naval Undersea Center. Leading the study was a committee of experts on such subjects as architecture, ocean engineering, marine systems, marine construction, and even social considerations. Senior architectural consultant for the project was Kiyonori Kikutake of Japan, with an international reputation for marine architecture. Parallel with the study, a seminar was held on "The City and the Sea," examining city planning, sociological and engineering factors in the design of floating marine communities.

The result of the 1971 study was an architectural-engineering design which could be realized by 1977 under normal growth and development and by 1976 under priority development. The study is continuing independently through state funding in an attempt to elaborate architectural and special utilization plans. This part of the study will be complemented by a course in Ocean System Engineering at the University of Hawaii in which the students will engage in a system design study for the marine exposition.

In the fall of 1971, NOAA approved an $85,000 Sea Grant for an engineering feasibility study of floating community design concepts.

As a part of this study, a 1/20th-scale model has been built and is being tested under simulated deep-sea conditions. The five major

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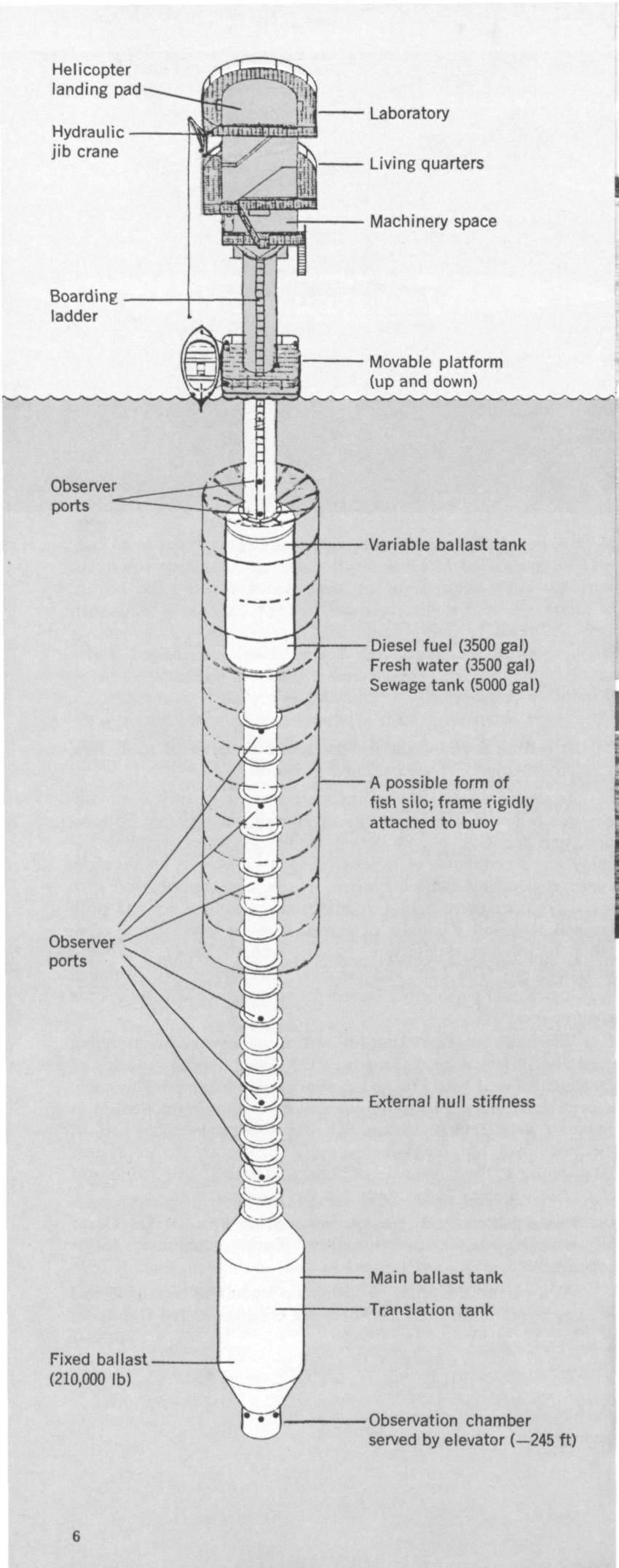
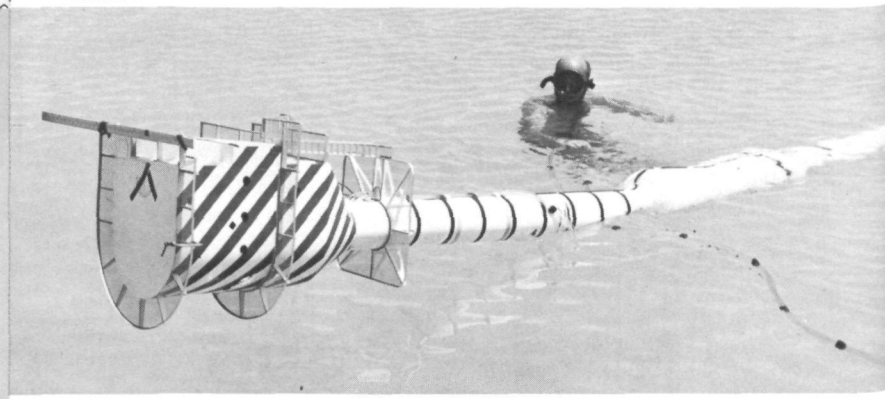
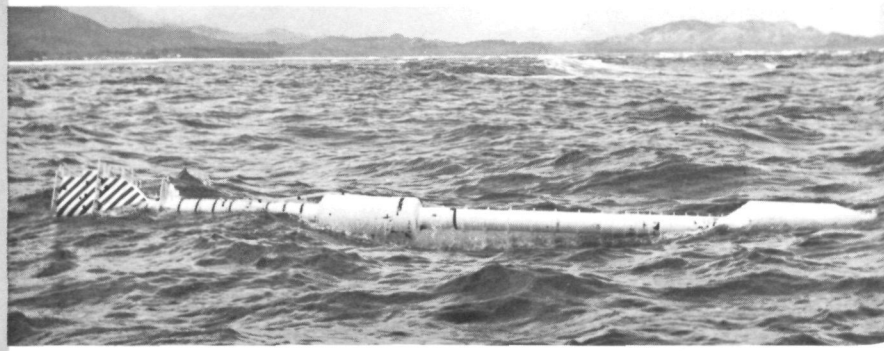






Oceanic Institute photographs

(Left) MOSES—Manned Open Sea Experiment Station being developed by the Oceanic Institute with support from Sea Grant—in the vertical position with a silo for marine animal culture. (Above) A scale model of MOSES is moved from vertical to horizontal position for towing. The striped portion would be laboratory-living quarters, the main ballast tank is at the other end, and near the middle are tanks for ballast, fuel, water, and sewage.

areas of engineering interest in this study have been defined as the mooring system and hydrodynamics, structures, construction, environment, and systems integration.

Another phase of the engineering feasibility study is a cost effectiveness analysis of the floating complex. Here, engineers and economists join in trying to predict the answer to the very basic question, "Is it worth it?" They describe the city not as a solid thing of steel, concrete, and glass, but rather in such terms as the skill and man-hour levels necessary for its construction and maintenance, the ways in which the complex will serve its human inhabitants, and the floating city's merits as compared with commu-

University of California, San Diego, photograph

Still another variation of the FLIP theme is found in plans for a 15,000-square-foot stable floating platform with legs which pivot from a horizontal towing position to the vertical on-station. This platform will be made of two units, each with two FLIP-like 350-foot concrete legs. The modules will be towed to their station in the horizontal position, the hinged legs will be flooded and swung down, and the two sections connected.

nities built on the coast and cities which are landlocked.

As this study continued this spring the state passed legislation to establish a commission for marine exposition and to prepare for the establishment of a public corporation or other appropriate mechanism to conduct the exposition.

So a 123rd Hawaiian island begins to take shape—in men's minds, on the drawing board, in the model tank—and suddenly it doesn't seem so incredible after all. Captain Cook's Sandwich Islands are growing. The bicentennial may see the beginnings of a new life style for future generations on our overcrowded planet as man—ever-ingenious—returns to the sea to live. □

The vertical cylinders which would support and lend stability to the "City With Sea Legs" are, perhaps, the structure's most eye-catching feature. Their concept, however, is nothing new to ocean engineers.

Marine experts see an ever-increasing use of stable deep sea platforms from which a variety of man's oceanic activities can be performed.

Such platforms could serve as mobile oil-drilling rigs, mineral mining surface facilities, nuclear power plants, weather stations, or fishing fleet bases. A number of military uses are apparent also.

The first of a long-legged family of ocean platforms (called FLIP for Floating Laboratory Instrument Platform and its rather unusual way of being set up) is showing the way. FLIP, the ship that sinks by the stern until it stands upright with only 55 of its 355-foot length above water, has become a familiar sight at ocean science project sites such as the Barbados Oceanographic and Meteorological Experiment (BOMEX) conducted in 1969. The idea for FLIP originated at the Woods Hole Oceanographic Institute as far back as 1956, though FLIP wasn't put to sea until 1960. FLIP's primary mission was to "listen" to the tiny wave motions in open water which cause refractions in sound. These refractions have been likened to the distortion or twinkle imparted to starlight as it passes through the earth's atmosphere. FLIP's success in hydroacoustic studies was enormous and Scripps began looking into the possibility of a larger FLIP-type platform to conduct even more elaborate oceanic experiments.

But more important, perhaps, was FLIP's success from the ocean engineering standpoint. The platform's stability has been repeatedly demonstrated in deep sea operations. The above-water portion could negotiate waves thirty feet high as the radically designed tube-like ship moved less than three inches up and down.

An intriguing application of the FLIP concept is the Manned Open Sea Experiment Station (MOSES) project which is being developed by the Oceanic Institute of Hawaii and is supported in part with NOAA Sea Grant funds. MOSES is a FLIP-like structure which is towed to its ocean station and flooded until it stands upright. Unlike FLIP, however, MOSES will be used for biological research. Its facilities will include laboratory and living space for eight scientists. Extending throughout most of the structure will be a hollow shaft with an internal elevator and viewing stations allowing a view of the open sea from almost any point along the station's length. From 40 to 70 feet below the surface a large bulge will contain variable ballast, fresh water and fuel supplies and sewage storage. (The scientists naturally must avoid polluting the water which they are studying.) A laboratory chamber is planned at the 230 foot depth.

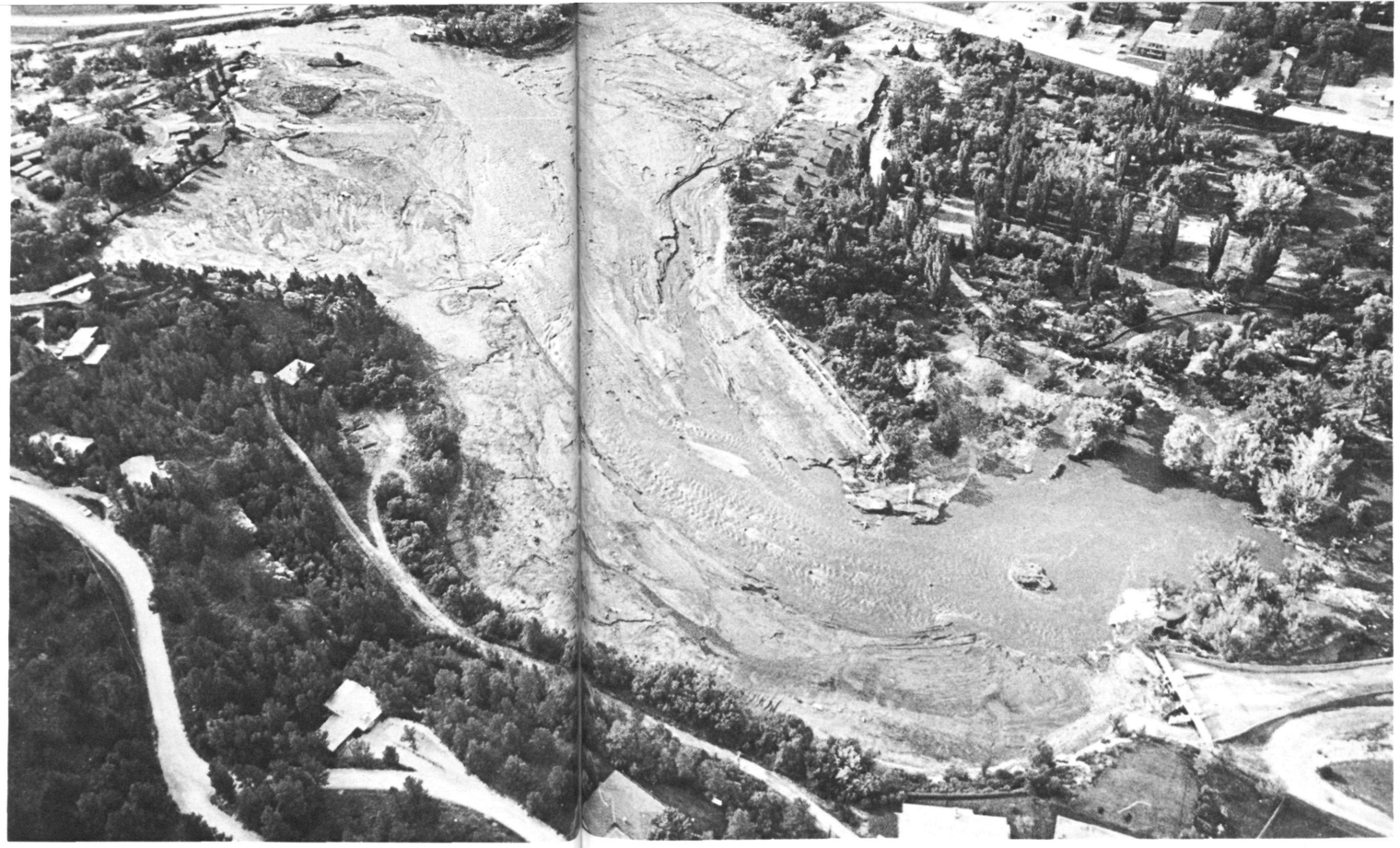
One research mission for MOSES involves the construction of a sort of silo around the shaft for the culture of marine animals using nutrient-rich water pumped in from a depth of 600 to 1,500 feet. Scientists in the shaft at the center of these "fish pens" would have a unique, first hand view of the animals' progress.

Still another variation of the FLIP theme is found in plans for a 15,000-square-foot stable floating platform with legs which pivot from a horizontal towing configuration to a vertical on-station configuration. This project, which culminates nearly three years of design study is under the joint technical management of the Advanced Research Projects Agency and the Office of Naval Research. This platform will be made of two units, each with two, FLIP-like, 350-foot concrete legs. The modules will be towed to their station position in the horizontal position, the hinged legs will be flooded and swung down leaving the platform portions horizontal, and then the two sections will be connected to form a single unit.

From FLIP to a city in the sea in less than a score of years? The technology is there and in the Space Age, man sets his own horizons.

Max Kohler, National Weather Service Associate Director for Hydrology, says new radar techniques and automatic sensors will vastly improve warnings of

THE FLOOD THAT STRIKES IN A FLASH



After the Rapid City, South Dakota, floods of June 9, 1972, Canyon Lake was gone. "It looked as though an insane giant had slapped his palm into the lakebed, emptying it," an eyewitness said. The lake emptied after the dam—its remains are visible at right—gave way, filling Canyon Lake Park with tons of mud and debris.
(Rapid City Journal photograph.)

Q. Mr. Kohler, are flash floods getting increasing attention from the National Weather Service?

A. Indeed they are. Among the reasons, of course, are the widespread and destructive flash floods along the Eastern Seaboard that were associated with Tropical Storm Agnes in late June, the flash flood in Rapid City, South Dakota, on the night of June 9-10, in which at least 226 people died, and the flood in West Virginia last February, which killed 118. Before that there was the unprecedented flooding from Hurricane Camille in 1969 in Virginia, which killed 153. All of these have generated a great deal of interest in improvement of warning services. We're trying to respond to that, along with a number of other agencies.

Q. Just how do you define a flash flood?

A. It's a relative term. There is no general agreement on what a flash flood is. We think of it as something that takes place within four to six hours after the storm that caused it.

Q. Are floods that result primarily from a dam failure, such as the one on Buffalo Creek in West Virginia this year, your responsibility?

A. We take the attitude that, wherever there is a possibility of flooding, we will do whatever we can to warn people. Generally speaking, however, we can be most effective where a flood is a result of a meteorological event; then we can combine the skills of weather forecasting with our understanding of stream and river flow. We don't have the resources to set up warning systems for people living immediately below every small dam that might fail. There are too many dams. Once a dam has burst, however, we may be in a position to warn people, if they are far enough downstream.

Q. Are flash floods becoming more prevalent, possibly because of manmade changes in our environment, such as paving over of grassland and replacement of forests with concrete, asphalt, and steel?

A. That is of course a factor, but I think the more important thing is that more people are locating themselves in areas that are subject to flooding. What may seem to be an increase in flash-flooding is in reality increased exposure.

Q. How many people are killed annually by floods, as compared to, say, tornadoes?

A. During the 10-year period 1961 through 1970, there were 857 deaths from floods, for an average of 86 a year, and 966 deaths from tornadoes, for an average of 97 a year.

Q. How many of the flood deaths were from flash floods?

A. We don't break the statistics down that way, but I would say most were from flash floods. Certainly, they were in recent years. The chief reason is the element of surprise, of course.

Q. We seem to be hearing more flash-flood watches and warnings broadcast over radio and TV these days. Is this something new?

A. Yes. Not until 1969, after the Camille flooding in Virginia, did the Weather Service begin using the same watch and warning system for flash floods as it has been using for so many years for tornadoes and hurricanes.

Q. Is the basic idea the same?

A. Yes. A flash-flood watch means weather conditions are such that a flash flood may occur; a warning means the water is on the ground and flooding is imminent. The watch is our way of providing that extra margin of time to get ready which can be so important with fast-breaking events. And occasionally it will be the only alert put out. There may not be enough time for a warning, too.

Q. What should people do when they hear on radio or TV that a flash-flood watch has been issued?

A. If you're in a flood-vulnerable area, it would be wise to plan just what you will do if you have to move to safer ground. Keep a weather eye out for signs of trouble. If you're traveling on roads subject to flooding, it might be smart to check your road map for a possible detour. If you're in unfamiliar territory or on unimproved roads, you might stop and ask local residents if they expect trouble ahead.

By all means, if you suspect the flooding might affect you, keep listening to your radio or TV for later bulletins from the weather office, and keep watching for early indications of flooding.

Q. Suppose the first thing I hear is the flash-flood warning for my area?

A. Act quickly to save yourself. You may have only seconds. Follow our flash-flood safety rules.

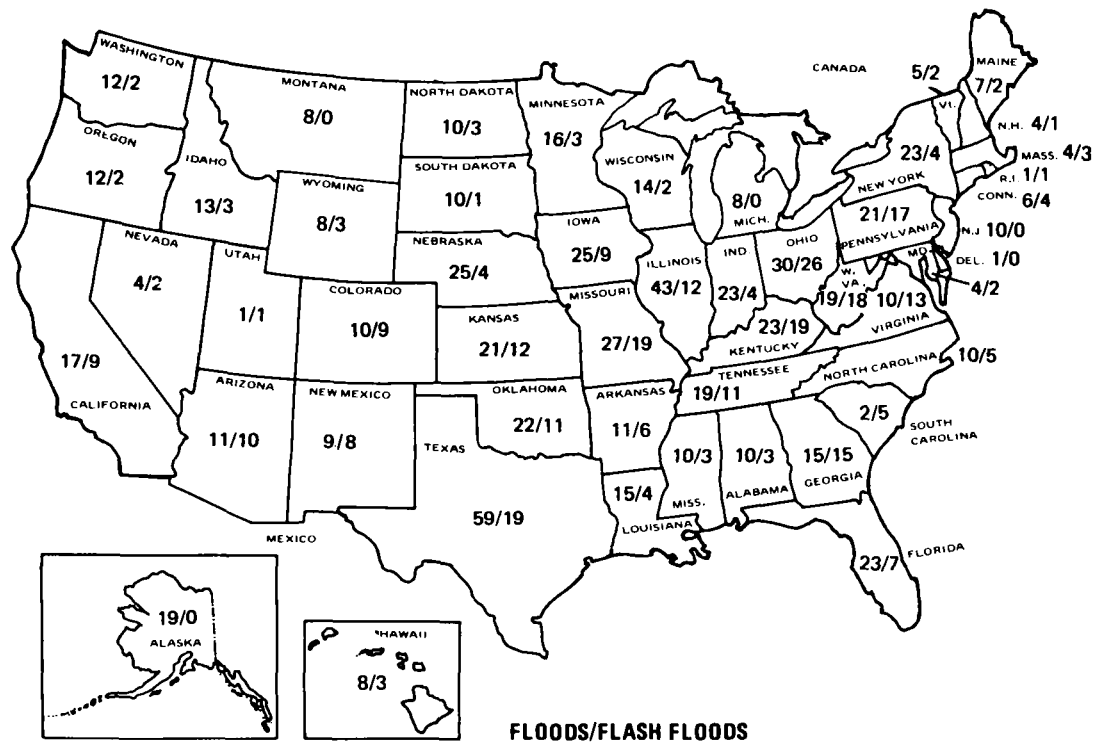
Q. Are you satisfied with our present system of warnings for flash floods?

A. No. There are many places in the country where we would have nothing in the way of reports in the nighttime during sudden, heavy rainfall. Many of these are flash-flood prone areas. At present only about 15 percent of our 5,000 reporting stations are telemetered so that we get precipitation reports day and night. In areas where we don't have telemetered networks, we're depending on local people to provide information on rainfall, and they usually report only during the day. So, for the most part, our warning system is a daytime system. We really need an automated system, working 24 hours a day.

continued

Edwin P. Weigel interviewed Mr. Kohler for NOAA Magazine.

Rains from Hurricane Camille brought flooding to large areas of Virginia in August 1969. (Top, left) The James River at Richmond, two days after the record rainfall. (Top, right) After the flood, cleaning up an inundated store at Scottsville, Va. (Middle, left) The downpour of 27 inches in eight hours carried away great patches of Virginia's hillsides. (Middle, right, and lower left) Mud slides tumbled houses down hillsides and covered roads with muck. (Lower right) Fortunately, this home in Howardsville, Va., was unoccupied on the night of August 19-20, 1969.
Photographs from the Virginia Department of Highways, Charlottesville Daily Progress, Virginia Department of Conservation and Economic Development, and the Richmond Times-Dispatch.



FLOODS/FLASH FLOODS

Number of Floods and Flash Floods in Which American Red Cross Assistance Was Given, 1955-1971—data from American National Red Cross.

Q. When you say a station is telemetered, what does that mean?

A. It means that observed amounts of precipitation or of stream level are telemetered to a Weather Service office without a human observer being on the scene. To get the observation for a given spot, a man in the weather office dials a designated telephone number for that gage and listens for a series of audible beeps separated by pauses. By counting the beeps in each series, he knows the level of water in a stream or the inches of water in a rain gage. For example, the first series of beeps might be three, then a pause, then four beeps, then a pause, then six beeps. So the number would be 346, which might indicate that a river was 34.6 feet above a certain stage.

Q. That seems a bit cumbersome. Are there plans to speed the process?

A. Yes, there are. The newer systems we'll be installing in a year or two will be automated so that the man at a station won't have to dial a number and count the beeps. The call-up will be made automatically and the information will be printed on a teletypewriter, so that the observer won't have to leave his radar screen. He will simply set this collection system in motion and refer to it from time to time to see what is happening at each gage.

Q. Does radar help you in locating areas of heavy rainfall?

A. Yes, it does, and we are using radar more and more. Experiments are under way which will let us get quantitative measurements from it. Until now, our use of radar has been qualitative. To understand the difference, you need to know how the traditional system works.

By the traditional method, when the observer sees a very bright echo on his radarscope that tends to remain in the same place, geographically, he may conclude that heavy rain is falling there, with a strong chance of flooding. He also may make a supplementary judgment based on cloud height—the higher the cloud top, the greater the precipitation.

Q. But he doesn't really know how much precipitation?

A. That's right. By conventional radar operation, he doesn't. We have tried to get around this problem at a dozen places in the East by clustering telemetered rain gages around radar stations. This system gives the radar observer a way to relate what he sees on his scope to what is falling on the ground. If he sees a strong echo in a certain area, he interrogates a nearby rain gage and finds out what is happening. Then, using a map that indicates the areas that are prone to flash floods, he can alert appropriate localities that trouble is on the way.

With this kind of radar umbrella over communities subject to flash floods, you have somebody watching over them all night long who has an idea of potential flash-flooding.

Q. And your new, quantitative system will be better?

A. Yes. It will involve an effort to put numbers—that is, inches of precipitation—on rainfall even before it hits the ground. It involves a new way of handling the radar information. We call it D/RADEX —for Digitized Radar Experiments. The heart of the system is a digitizer and a minicomputer connected to the radar.

D/RADEX is now being used experimentally in Oklahoma City; Fort Worth, Tex.; Kansas City, Mo., and Monett, Mo. Essentially it differs from the ordinary radar operation in that it gives you numerical values—from 1 through 9—for the strength of the echoes from a pattern of points inside a cloud system, instead of an image on a radar screen whose parts are of varying brightness. This means that the radar observer will be able to use numbers for what he sees, instead of having to resort to crude adjectives such as "intense" or "heavy" covering relatively large areas of rainfall.

We'll have to spend some time calibrating the D/RADEX system, though—relating the 1's through 9's to inches of rain—before we can use it. We will do this by comparing what it gives us with the results from our old system of rain gages which has been in use for so many years.

continued

Q. How accurately do you think you'll be able to translate the D/RADEX return into inches of rainfall?

A. That remains to be seen. There have been a lot of tests. I suppose that we will be able to come within, say, an inch or two with a six-inch deluge. We are confident that D/RADEX, when perfected, will allow us to give much better warnings. We will be able to measure and keep track of heavy rainfall as it is occurring and consequently issue flash-flood warnings much sooner and more precisely than is now possible.

Q. Any other new techniques to speed warnings?

A. Yes. We have a new automatic flash-flood sensor. The first of these went into place near Wheeling, West Virginia, this spring. Others are being installed elsewhere in the East this year. Ten of them have been funded; at least that many more may be forthcoming. These are float-type devices—like a bulb in a toilet tank—that you mount on a bridge abutment or some other spot where rising water will affect it, so that a flash flood will activate an electrical signal. This signal is carried by connecting circuitry several miles downstream to sound a buzzer or set off a flashing light in a police or fire station—someplace manned 'round-the-clock. From here warnings can be passed to the public by means of radio and TV or possibly by siren.

This is a cooperative program. The Weather Service pays for the water-level sensor, and the audio or visual alarm system, and their maintenance; the local community pays utility costs.

Q. How much does such a system cost, for equipment and installation?

A. Roughly $3,000.

Q. Will NOAA's new Geostationary Operational Environmental Satellite, slated for launch late in 1973, help you in transmitting flash-flood communications?

A. Indeed it will help us improve flash-flood communications. Although the primary mission of GOES will be indirect sensing of electromagnetic radiation in the visible and infrared ranges—mapping and picture-taking functions—it will also serve as a data-relay satellite—passing along weather information from stations anywhere within its field of view. It should be able to interrogate and pass on data from as many as 10,000 stations, including rain and river gages, buoys, ships, aircraft, and perhaps balloons.

Q. How will it be better than existing communications systems?

A. It will be most useful to us at first in rugged, mountainous areas such as the Columbia Basin in the Pacific Northwest, where the initial GOES network will be established. In such areas, land lines are difficult to maintain or nonexistent, and the radio frequencies we have been assigned to use are extremely expensive to operate because the signals travel by line of sight, requiring frequent relay stations.

Q. Could you elaborate on that a bit?

A. Well, you will start with an automated rain gage or river gage, the same sensing equipment we now interrogate by telephone. When using GOES, instead of sending the signal horizontally through a wire or by radio relays, you will have the sensor radio it up to the satellite, which will relay it back down to the receiving station at Wallops Island, Virginia. The signal will then go over existing land lines of the Weather Service to our forecast offices needing the data. Instead of having perhaps 10 or 15 radio relay stations passing the signal along over rugged terrain, you will have just one relay station—that is, the satellite.

It will be seeing 48 states and southeastern Alaska.

Q. How many relay stations on the ground will the satellite save, all told?

A. Well, the question is hypothetical because you wouldn't install on the surface all the land-line and relay-station capability the satellite could provide. But some existing radio networks of this type in rugged terrain have just about as many relays as sensors. So with 1,000 observing stations you might have 1,000 relay stations. The satellite would take the place of all but one of the latter.

Q. Then the satellite will let you do things that were out of the question before because of the cost—right?

A. Yes, but bear in mind that the main function of GOES will be viewing global weather patterns. The data-relay capability becomes available at relatively little increase in cost. The satellite, from its fixed position 22,300 miles high over the Equator, will provide forecasters with a steady stream of cloud photographs on a real-time basis, day and night. This will greatly enhance our ability to spot, track, and forecast the growth and movement of severe storms which may produce heavy rainfall.

Q. With these sophisticated devices coming along, how do you visualize the flash-flood warning system of the future? How good will it be?

A. We should be able to issue detailed flash-flood forecasts in situations where now we can issue only flash-flood warnings some hours after the water is on the ground. We should be able to do this within an hour after a heavy rainfall has occurred—being very specific about just who, up and down the slope, will be affected, and just how high the water will rise. Instead of a generalized warning that there is high water coming, over a large area, people will be told whether it is really going to affect them. Improved technology will let us narrow the warning to those actually involved.

Q. Cooperative efforts by the communities involved will continue to be important, won't they?

A. Yes, they will. These cooperative programs are already doing a good job.

Q. How do these cooperative systems work? How many are there?

A. Right now, even without a lot of sophisticated new equipment, there are 138 flash-flood warning systems in the U.S. that make use of a combination of Federal and local personnel to issue warnings. Some of these go back almost 20 years, and resulted from early work we did with the American Red Cross. Most of them came into being after a bad flood. Many of these cooperative systems make use of rainfall and streamflow observers at key points who telephone their observations to a central location. From these, high water can be forecast downstream, based on previous calculations.

Q. How does a community go about arranging for such a system?

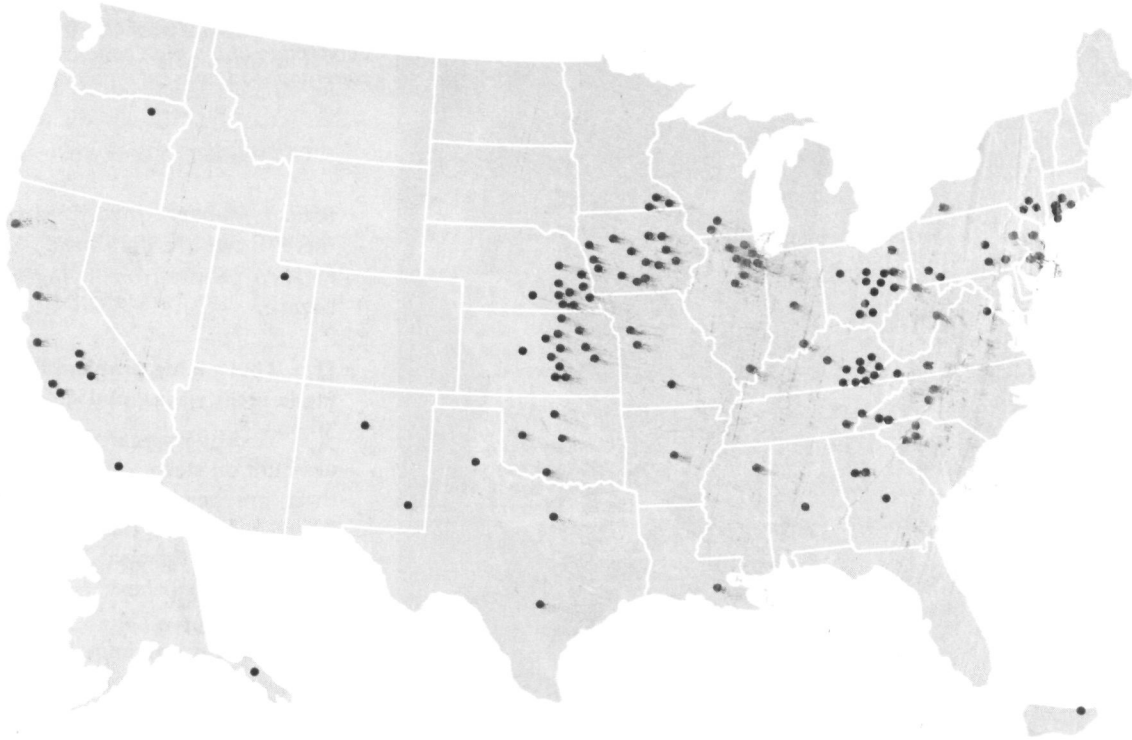
A. We can arrange for them to get copies of typical plans now in existence. Canton, Ohio, has a good one. It includes radar surveillance and telemetered rain gages. It has been in operation for 10 years.

Q. Do you believe there should be a lot more such systems?

A. There undoubtedly are many, many more places which would benefit from flash-flood warning systems. Certainly, West Virginia could use more, and other mountainous areas, too. Resort and vacation areas in some states could use them. Streamside campers are often caught unaware. There have been several such incidents with heavy loss of life, especially one in Arizona in September 1970, when 23 people were drowned, most of them campers.

FLASH-FLOOD WARNING SYSTEMS

The following communities have an operational flash-flood warning program:



ALABAMA
Centerville

ALASKA
Juneau

ARKANSAS
Little Rock

CALIFORNIA
Carmel
Contra Costa County
Kernville
San Diego County
Santa Barbara County
Santa Maria
Springville
Three Rivers
Van Duzen

CONNECTICUT
Ansonia
Beacon Falls
Hartford
Naugatuck
Waterbury

GEORGIA
Atlanta
Macon
Norcross

ILLINOIS
Arlington Heights
Deerfield
Des Plaines
Harrisburg
Joliet
Lake Forest
Northbrook
Wheeling
Willow Springs

INDIANA
Corydon
Indianapolis

IOWA
Ames
Atlantic
Cedar Rapids
Charles City
Des Moines
Fort Dodge
Logan
Marshalltown
Mason City
Pisgah
Sioux City
Spencer
Waterloo
West Des Moines

KANSAS
Abilene
Barnard
Clyde
El Dorado
Frankfort
Hays
Newton
Ottawa
Salina
Topeka
Washington
Wichita

KENTUCKY
Barboursville
Baxter-Harlan
Cumberland
Martin
Oneida
Paintsville
Pineville
Taylorsville
Whitesburg
Williamsburg

LOUISIANA
Baton Rouge

MINNESOTA
Austin
Houston
Rochester

MISSOURI
Ft. Leonard Wood
Kansas City
Smithville

MISSISSIPPI
Tupelo

NEBRASKA
Fort Crook
Grand Island
Irvington
Ithaca
Lincoln
Norfolk
Omaha
Roca
Salt-Wahoo
Seward

NEW JERSEY
Asunpink Creek
Hackensack
Trenton

NEW MEXICO
Carlsbad
Santa Fe

NEW YORK
Livingston Manor
Olean
Poughkeepsie
Rosendale

NORTH CAROLINA
Biltmore
Elkin
Rosman
Wilkesboro

OHIO
Bourneville
Canton
Chillicothe
Columbus
Independence
Killbuck
Mansfield
Mt. Vernon
Newark
Ottawa
Uhrichsville
Willoughby

OKLAHOMA
Blackwell
Cheyenne
Guthrie
Waurika

OREGON
Pendleton

PENNSYLVANIA
Camp Hill
Canadensis
Carnegie
Greensburg
Langhorne
Williamsport

PUERTO RICO
San Juan

SOUTH CAROLINA
Clifton
Gaffney
Greenville

TENNESSEE
Gatlinburg
Spring City

TEXAS
Halton City
Palo Duro State Pk.
San Antonio

UTAH
Flaming Gorge

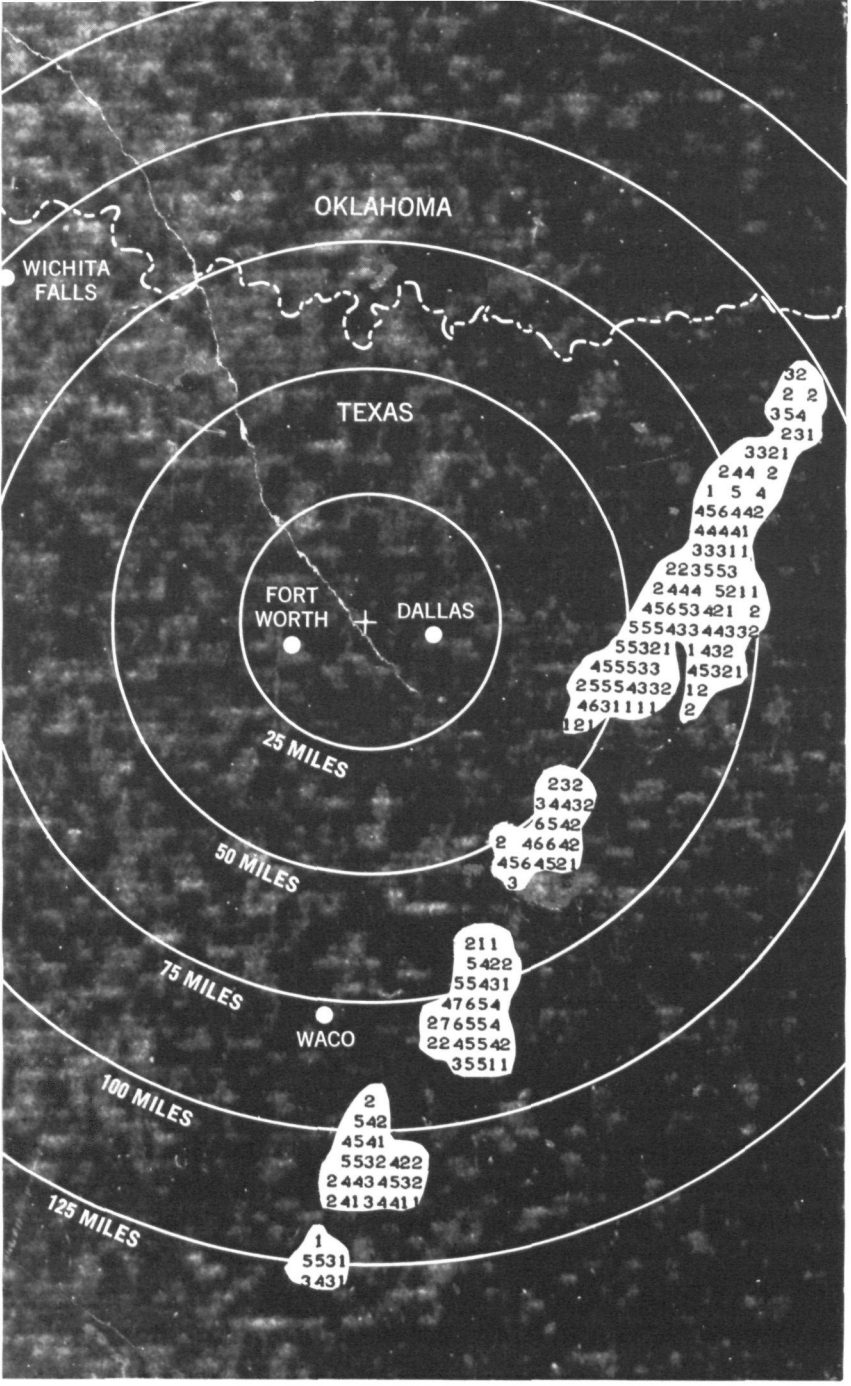
VIRGINIA
Alexandria
Big Stone Gap
Covington

WISCONSIN
Blanchardville
Darlington

WEST VIRGINIA
Elkins
Wheeling

Rescuing victims of a flash flood in New Mexico.
(Artesia, N. Mex., Daily Press photograph.)

continued



An experimental radar system produces numerical values for the strength of echoes, which can then be correlated with rainfall intensity. (Left) An artist's conception of the digitized display, superimposed on a satellite photograph.

Q. What criteria do you use for determining whether a community or area should have a flash-flood warning system?

A. Until recently, we have simply worked with localities that have experienced bad flooding in the past. Since the Camille flooding in Virginia, however, we have designated some of our experts in the field to work actively on the problem of making surveys before a flood makes the need obvious.

Q. How much of a job would it be to make such an analysis for the entire country?

A. It would be a huge task. There would be a tremendous number of specific situations to analyze; and those situations are constantly changing. But the idea is being explored now.

Q. Would this take in all the potential disaster areas, including those like Buffalo Creek, where a rupture in a dam was the prime cause of the flash flood?

A. Possibly. But small dams, made of earth or coal-mine waste, as that one was, are a special category. They are more of an engineering problem—making sure the dams will hold—than a hydrometeorological problem, involving weather. Rainfall wasn't the big factor there; it was the dam itself. A related aspect is political—regulations to keep people from living in areas where there is a known flood hazard.

Q. That's a big problem in southern California, isn't it? Overbuilding in areas where mud slides from heavy rains are a recurrent threat?

A. Yes. Every year that goes by, more and more California homes are built on steep slopes subject to sloughing off of the soil whenever there are heavy rains. Better warnings won't solve that problem. There is evidence that people are aware of the hazard, yet they continue to take the risk. Efforts to deal with it by better zoning aren't having much success.

Q. Is this a problem, generally—people building or buying homes in areas of high flood-risk?

A. Yes, it is.

Q. How about the conscientious home buyer, who wants to avoid flood danger? How can he find out, in advance, if a home he's interested in is a bad risk?

A. Usually the city or county engineer, or their counterpart will be able to provide the flood history for the area. Or he might check with the local newspaper. There will be articles on file telling about serious floods of the past.

Q. Are Government agencies doing anything to curb this trend toward over-building in flood-prone areas?

A. Yes, they are. Under the Federal flood-insurance program, which of course is highly subsidized, part of the requirement for putting the program into effect is that the states will develop zoning systems to keep people from building in flood-prone places. The law requires a delineation of flood-hazard areas, so the situation should take a turn for the better as the flood-insurance program begins to make itself felt. In areas where a flood risk exists but is within permissible limits for habitation, mortgage companies will insist that home buyers buy flood insurance, adding to the cost of the homes. This, too, will act as a deterrent.

Q. Looking back on the historical record, how did people die in flash floods? What did they do wrong, or neglect to do? And how many deaths were apparently unavoidable, with existing limitations on technology?

A. Well, we still have to face the fact that there are certain types of situations right now where even our most sophisticated systems for detecting and issuing warnings for flash floods won't do the job completely. Examples are the Rapid City flooding and the Camille flooding in Virginia, which began when many people were asleep. Unless we can arrange for some sort of automatic alarm system right inside the homes of persons living in vulnerable areas, they may not be aware of a problem because they won't be monitoring their radio or TV. Not until we get a reliable home-alarm system—perhaps one where we can automatically turn on your radio or TV when there is a warning to be announced—will that problem be solved.

Moving then from this extreme category—where people are doomed unless warned immediately that they must leave their homes

because the structures themselves are about to be washed away—I would list the next most-frequent cause of casualties as motorists taking unnecessary chances. One such situation involves the motorist who gets stuck in a flooded area of the road and won't abandon his car immediately but tries to save it. In so doing he and perhaps his passengers get trapped and washed away. This happened near Baltimore two years ago at the cost of eight lives—the driver, two passengers, plus four volunteer firemen and a tow-truck operator who were trying to help save the car.

Then there is the motorist who deliberately drives from safe ground into a flooded area and tries to reach high ground on the other side. Too late, he learns that part of the road has been washed away; his car rolls into the stream and the occupants drown.

Q. The lessons here?

A. Unless you are very certain that the danger of remaining where you are is greater, don't try to drive a car over a flooded highway. If the car stalls, leave it. Don't try to push it to safety.

Q. Any other dangerous practices to avoid?

A. Yes, I want to say a special word to campers. Be extremely cautious about pitching your tent or parking your trailer beside a stream. Remember that the storm which causes sudden flooding may not even produce rain where you are—so that the first thing you are aware of is water rising around you. Pick a spot where there's plenty of sloping bank separating you from the water's edge. And it's a good idea to have a portable radio handy so you can listen to the latest weather forecast before you turn in for the night.

Q. How about hurricanes? They frequently spawn flash floods, don't they?

A. Yes. As Agnes demonstrated so clearly in June, hurricanes and flash floods go together. Hurricanes invariably contain an enormous quantity of rainwater which will be dumped as the storm moves inland. Sometimes this is combined with the storm surge—a tide of wind-driven ocean water—to produce cataclysmic effects. Even many miles inland and days after the hurricane makes landfall, hurricane rains can cause a catastrophe. The remnants of Camille, which, as we said, drowned 153 persons in Virginia, did so two nights after that storm made landfall on the Gulf coast of Louisiana and Mississippi. The storm traveled northward about 700 miles and then made almost a right-angle turn across the Appalachians before releasing anything more than nominally heavy rainfall. Then came the deluge —27 inches in eight hours.

Hurricane Diane, in August 1955, was another striking example. Heavy rainfall on previously saturated ground caused severe flash floods over the entire Northeast, much of this miles inland. Damage exceeded that from any prior storm of record.

So, when a hurricane is making landfall, don't think you are completely free from its effects just because you don't live right on the coast. Listen for flash-flood watches and warnings as it moves inland. And even if you don't receive a warning, keep alert for danger signs. If the rain starts coming down in torrents, start thinking about whether your house will remain safe for occupancy. If in doubt, move to a sturdier structure in a protected location, or go to some safe area, such as a hilltop or a high plateau.

Q. What suggestions do you have for the media—newspapers, radio, and television—to help you save lives from flash floods?

A. Newspapers can help us by printing our flash-flood safety rules —perhaps annually—before the rainy season, and by their articles—grim though they may be—about people who lose their lives in floods. When there is a threatening situation, radio and television broadcasters, without whom we would be helpless to spread warnings, should make certain they always have the very latest Weather Service bulletins and that these are broadcast promptly. The messages should be delivered calmly; panic is one of the greatest dangers. Rumors should be withheld; only verified information should be put on the air, to avoid compounding the confusion. Above all, broadcasters should try to work closely with the local weather office and local public-safety officials such as the Defense Civil Preparedness Agency (formerly called Office of Civil Defense), department of public works, and state and local police and fire departments—agencies that are experienced in dealing with disasters.

Make it a team effort.

MAX A. KOHLER

The Nation's new chief flood forecaster got his first look at a flood when he was 13 years old, surrounded by the swirling waters of the Neosho River in Council Grove, Kansas. It was the worst flood of record on that river up until that time, and it is still a vivid memory to Max A. Kohler.

In January, 1940, at Roswell, New Mexico, Mr. Kohler began his career with the Weather Service (then Weather Bureau) as a Meteorologist Intern. Transferred to Weather Service headquarters in Washington, D.C., as a Junior Hydrologic Engineer, he went to work in 1942 in the Office of the Hydrologic Director as Assistant Hydrologic Engineer.

Four years later, in July, 1946, Mr. Kohler was named head Hydrologic Engineer in a research unit of the Office of Hydrology. Two years after that he was promoted to chief of that unit.

In August, 1953, he was named Chief Research Hydrologist. Early in 1965, he was named Chief Hydrologist and since 1969 has also been serving as Director of the Research and Development Laboratory in the Office of Hydrology.

Mr. Kohler has been very active in the World Meteorological Organization and has traveled abroad extensively in this connection. He served as President of the World Meteorological Organization's Commission for Hydrometeorology from 1961-68.

He was President of the American Geophysical Union's Section of Hydrology from 1968-70. He is now Chairman-elect of the American Association for the Advancement of Science's Section on Atmospheric and Hydrospheric Sciences, and a member of the Council of the American Meteorological Society.

In 1949, Mr. Kohler received a Commerce Department Silver Medal (together with Messrs. Foskett and Linsley) for his part in development of an electronic flood-routing machine, and in 1959, he was awarded a Commerce Department Gold Medal for outstanding service.

TERROR IN THE NIGHT!

The flash flood that swept down from the Black Hills into the resort community of Rapid City, South Dakota (population 43,000), on the night of June 9-10, followed a classically sudden and terrifying pattern for these killer torrents.

Despite the fact that many people fled to safety after hearing radio and TV warnings from the National Weather Service and state and local public-safety officials, many others were trapped, asleep in their beds or perhaps driving along a road, when the raging waters struck. Some ignored the warnings.

As do so many flash floods, this one did its worst in the middle of the night. It struck an area where not in living memory had so-concentrated a downpour fallen in so short a time. (Rainfall totaling 15 inches—nearly equal to the yearly average—fell in only six hours at some spots in the creek basins just above and west of Rapid City.) A number of the victims were out-of-state visitors unfamiliar with the terrain and unaware of possible sources of warnings. A dam on Canyon Lake on the western outskirts of Rapid City gave way about 10:45 p.m. This produced a momentary surge or surges of water that contributed to an unknown extent to a catastrophe already inevitable because of the sheer volume of water in the drainage basin.

Amazement, shock, and horror were standard reactions reported by those engulfed who miraculously survived, or who looked on as normally picturesque creeks were transformed into roaring monsters. Perhaps the best way to tell the story is by a review of accounts by newspaper reporters at the scene of the worst individual flood disaster since spring flooding in the Mississippi Valley in 1927 killed 313. (Two weeks after the Rapid City flood, known dead totaled 226, with 58 still missing. Property damage was estimated at 100 million dollars.)

What follows are condensations and excerpts from stories filed by newsmen at the scene of the disaster. The goal in presenting them here is to convey to others what to expect in future flash-flood situations, and to encourage swift response to warnings when issued—anywhere, anytime.

Jerry Mashek, Rapid City "Journal"—For me it started as sort of a lark. At about 8 p.m. there were reports of high water along Rimrock Highway west of Rapid City. We decided to go up for some pictures.

I knew it was raining hard, but there didn't seem to be any real danger. The water from Rapid Creek was running across the road in some places, but our pickup truck made it through in pretty good shape. Then it started to look more serious. We kept heading toward Hisega (a town 10 miles west of Rapid City).

Then the rain really hit. We watched in amazement as a small roadside rivulet turned into a four-foot-wide torrent. We headed back, but were halted with other vehicles by a three-foot wall of water spilling across the highway. At least one bridge was out. We decided to wait in the pickup and hoof it into town in the morning.

Rapid Creek, about 40 feet off to the right, sounded like a freight train passing in the night. The normally clear and placid creek was swollen to a torrent more than 150 feet wide. We could hear people trapped in houses on the other side of the creek calling plaintively for help. It was pitch black; rain was falling in sheets. All we could do was listen. How many were swept to their deaths there I'll never know.

The horror of life torn apart took its first hold on me.

At dawn we decided to hike toward Rapid City about three miles east. The devastation was unbelievable as we picked our way down this major Black Hills highway. Gigantic blocks of asphalt and concrete were strewn across what had been the roadbed. Bridge structures were ripped and dangling.

Mud was everywhere. Once beautiful homes had been obliterated. Articles from a shattered world lay scattered . . . here a shoe, there a table top, beside us a crushed toy. As we slogged down the highway we came to the fish hatchery on the outskirts of the city. Rearing ponds were under water, offices smashed. We could see where the creek had come out of its banks by around 400 feet.

The horror took a firmer grip on me. Here and there little knots of people stared blankly at their homes . . . or where their homes had been. Several survivors were perched on roofs.

Near once-beautiful Canyon Lake Park the nauseating smell of propane gas from ruptured tanks was almost overpowering. Canyon Lake was gone. Rapid Creek rushed through a sea of mud, automobiles and home furnishings. It looked as though an insane giant had slapped his palm into the lakebed, emptying it. The dam at the lower end had been ripped from its stone anchors.

And the horror brought my gut up into my throat. The park was like a desolate moonscape . . . giant trees uprooted, picnic tables, playground equipment, articles of everyday life choking the land. The beautifully manicured grass had huge gouges in it. Where there wasn't mud, huge rocks lay about.

And then we saw it. A body lay half-hidden in a jumble of wreckage. And the horror of life torn apart was the only thing on my mind. I didn't want to see any more.

Harold Higgins, Rapid City "Journal"—I went to the Fifth Street bridge after 11:30 p.m. Friday to get a picture of the flooding. I figured my newspaper would want some shots because it was said to be one of the worst floods in years.

With my 35-millimeter camera and a strobe light around my neck I sloshed up the sidewalk in sneakers and jeans. When I got to the bridge, water was flowing around the ends and across the road. I took a few shots and stood back for a moment.

I was standing in the middle of the road when a four-foot bank of water came down the creek. It extended 50 yards on either side of the creek levee. Riding on the large wave like a surfboard was a blue, 30 to 40-foot house trailer.

I tried to take a quick shot of the oncoming bank of water, but water rushing against my legs made me unsteady. I had to grab a nearby mailbox post to keep from falling. The water was now a little higher than my waist, the current strong. By hand-pulling along a fence and then the bridge I worked my way to higher ground. Pieces of wood and other debris kept hitting my body and throwing me off balance.

I trudged off to the "Journal" office. The staffers were all out covering the flood. I walked to the fire station. Fire Chief Ken Johnson asked if anybody wanted to help rescue people. I answered yes, along with four other men. Two firemen had command of our team. We climbed aboard a truck. The driver headed for First Street to investigate a report of children stranded on a house trailer.

We shouted and whistled for a few minutes, but there was no response. With all of us hanging onto a safety line we waded down the railroad tracks into deeper water. Nothing. We inched back to the truck. Faint shouts were heard from where we had just been. We waded back. The person in trouble was a middle-aged man in slight shock. The two professional firemen got to him.

We returned to the station and ate sandwiches and doughnuts.

Six buildings were blazing along the creek. Firemen couldn't get to them because of the high water. Also, the fire chief had decided rescue missions were more important than burning buildings.

The next task lasted until dawn—to ride around the city looking for people in trouble. We helped some persons to land from practically submerged cars, gave out sandwiches to the hungry, asked questions about the missing. We walked in cold, knee-deep water among flooded and wrecked houses.

Shining flashlights into dark, soggy houses we discovered a variety of forgotten pets, a frightened 83-year-old woman, a very young baby all alone, and a woman face down in a flooded basement.

With dawn, I decided to leave my group and see what was left of my apartment. I expected to see it flooded. I walked along the bank to where my house had been. My house and two next to it had burned. Even the ashes were swept away. Just about everything I owned was gone, except what I wore and a mud-clogged camera.

Robert Hagen and Dale Fetherling, Minneapolis "Tribune"—A terrifying ride down a rain-swollen South Dakota creek brought death to three Twin Cities youths who were among six area young people on a camping trip and high-school graduation party in the Black Hills Friday night.

The three survivors told a harrowing tale of being trapped in their floating cabin, which was swept away and demolished in weekend flooding near Keystone, S.D., 20 miles southwest of Rapid City. The six had left in a van for Keystone soon after graduation. Because of heavy rains, they rented a cabin Friday night instead of pitching their tent. A small creek ran behind the cabin.

Bruce Glover, 17, one of the survivors, said the young people heard water running later and "tried to get the cabin door open, but the current was so strong we couldn't push it open. So we broke a window. But just as we were about to get out, a car came floating down and smashed into the window."

Water already was knee-deep inside the cabin, Glover said. "We all got onto the bed and hung onto the mattress, hoping it would float. But the cabin started crunching and it broke away from the foundation and started drifting away."

The cabin floated for a few minutes, then "a wall came apart and in another few minutes, the mattress sank. We tried to hang onto each other," Glover recalled, "but the current just tore us apart. I think I floated about half a mile."

The three who drowned were not seen again by their companions after the mattress sank.

Glover finally climbed onto the roof of a gas station. The other two survivors, Michael Kovacovich and William Gagne, managed to reach the roof of a souvenir shop.

Kovacovich said he was being smothered beneath debris as he was carried along. "I thought I was going to die and then I popped to the surface. I grabbed hold of something. It was a rainspout, so I climbed up on the roof," which Gagne already had reached.

"It was just sheer luck that we got out," said Kovacovich.

(Above, left) Keystone, South Dakota, was largely demolished by the flash flood that swept down from the Black Hills on the night of June 9-10, 1972. (Above right) The flood waters left cars and trailers piled in heaps in Rapid City. (Left) As head of the NOAA disaster-survey team that investigated the Rapid City floods and the flood-warning system, Donald C. House, at right in light suit, met with the Common Council of Rapid City to discuss the establishment of a temporary flood-warning system to protect cleanup workers and the possibilities for long-term improvement in flood warnings for the area. At the head of the table is Rapid City Mayor Donald V. Barnett; Joseph Strahl, Chief of the Operations Branch of the National Weather Service's Office of Hydrology, is seated to the right of Mr. House.

FLASH FLOOD

Flash-flood waves, moving at incredible speeds, can roll boulders, tear out trees, destroy buildings and bridges, and scour out new channels. Killing walls of water can reach 10 to 20 feet. You won't always have warning that these deadly, sudden floods are coming. But you can save yourself—your family—if you know what to expect and how to react.

Before the flood know the elevation of your property in relation to nearby streams and other waterways. Investigate the flood history of your area and how man-made changes may affect future flooding. Make advance plans of what you will do and where you will go in a flash-flood emergency.

When a flash-flood watch is issued listen to area radio and television stations for possible flash-flood warnings and reports of flooding in progress from the National Weather Service and public-safety agencies. Be prepared to move out of danger at a moment's notice. If you are on the road, watch for flooding at highway dips, bridges, and low areas due to heavy rain not observable to you, but which may be indicated by thunder and lightning.

When a flash-flood warning is issued for your area act quickly to save yourself. You may have only seconds. Get out of areas subject to flooding. Avoid already flooded areas. Do not attempt to cross a flowing stream on foot where water is above your knees. If driving, know the depth of water in a dip before crossing. The road may not be intact under the water. If the vehicle stalls, abandon it immediately and seek higher ground—rapidly rising water may engulf the vehicle and its occupants and sweep them away. Be especially cautious at night when it is harder to recognize flood dangers. When you are out of immediate danger, tune in area radio or television stations for additional information as conditions change and new reports are received.

After the flash-flood watch or warning is cancelled, stay tuned to radio or television for follow-up information. Flash flooding may have ended, but general flooding may come later in headwater streams and major rivers.

Flash flood means the occurrence of a dangerous rise in water level of a stream or over a land area in a few hours or less caused by heavy rain, ice jam breakup, earthquake, or dam failure.

Flash-flood watch means that heavy rains occurring or expected to occur may soon cause flash flooding in certain areas and citizens should be alert to the possibility of a flood emergency which will require immediate action.

Flash-flood warning means that flash flooding is occurring or imminent on certain streams or designated areas and immediate precautions should be taken by those threatened.

A movable habitat was home for diver-scientists exploring the coral reefs

BY ANN WEEKS

A strange duo of research vessels has made possible a detailed look at living coral reefs from a variety of scientific viewpoints, and in so doing paved the way for increased use of portable habitats in underwater research.

A tiny (eight by ten feet inside) portable habitat EDALHAB and her big (105 feet long) catamaran mothership LULU closed up shop in southern Florida on April 18 after successful completion of NOAA's Florida Aquanaut Research Expedition (FLARE), and returned to their home bases in New England. In their three-month project in Florida waters the odd couple had provided lodging, transport, and back-up services for seven scientific teams investigating the geology, environment, natural history, and ecology of coral reefs, in both basic and applied research projects.

NOAA participants working underwater and on the surface were from the MUS&T (Manned Undersea Science and Technology) office which was in overall charge of the operation, and from several National Marine Fisheries Service laboratories, the Office of Sea Grant, and the Atlantic Oceanographic and Meteorological Laboratories (Miami). Participants also came from nine colleges and universities, and independent research institute and three museums.

Although the scientific teams that took part in FLARE pursued different research goals, they shared two objectives: to increase scientific understanding of coral-reef ecology, and to test under stressed conditions the technological possibilities of a movable habitat supported by a surface vessel.

The depth at which EDALHAB was anchored during all projects—45 feet— permitted divers to range to greater depths and move freely in a wide circumference and obviated the need for special breathing systems. The divers were able to breathe air identical to that at sea level (80 percent nitrogen to 20 percent oxygen) under the increased pressures experienced at depths, within strict limitations. After about 24 hours blood and tissue adjust by becoming "saturated" (filled to capacity) with the greater gas concentrations caused by the higher pressure. For medical reasons, no missions were permitted to extend beyond the five-day mark—standard procedure when divers breathe ordinary air. As an additional safety margin, however, the standard operating procedure during FLARE was to return all aquanauts to the surface after four days, and hurry them into the decompression chamber aboard LULU for a 19-hour stay.

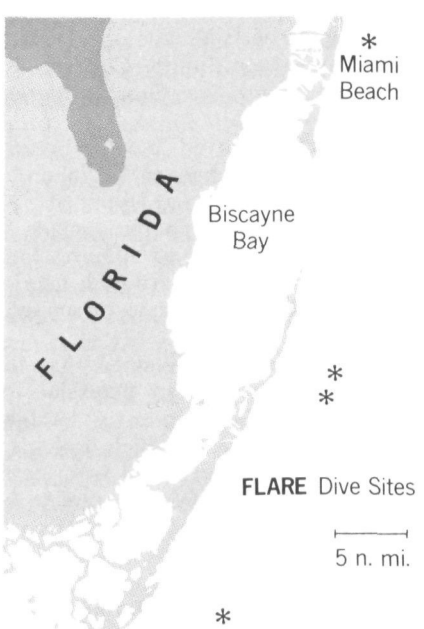
Medical arrangements were directed by Drs. William H. Hulet and Ronald Samson of the University of Miami and Dr. James Dickson of the University of Pennsylvania. Diving supervisor Thomas Mount or his assistant A. J. Ikehara (from the Rosenstiel School of Marine and Atmospheric Science, University of Miami), kept a careful watch on the aquanauts at all times, but particularly during decompression. The team of five permanent support divers and some dozen temporary ones was funded by NOAA's Sea Grant Office through its Miami regional office.

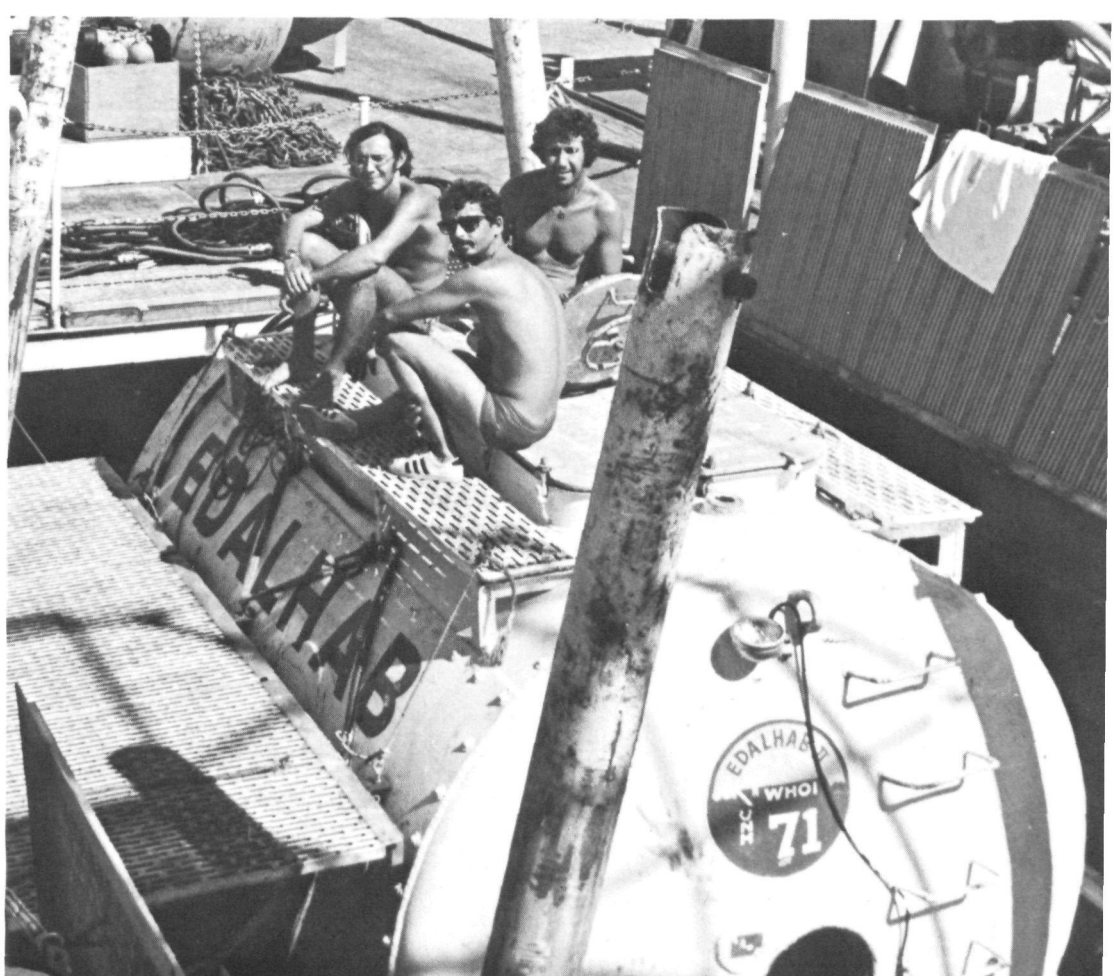
Three of the four reefs under scrutiny were considerably distant from inshore Florida Key reefs presently said to be imperiled by land-based dredging for construction purposes. Prolonged scientific study of these important underwater features has not been possible until recently, and the FLARE aquanauts all agreed on one point: More questions than answers developed as a result of FLARE studies, and a stepped-up program of reef research is essential to the welfare of U.S. coastal regions.

FLARE sites of investigation were over Long Reef and at adjacent Pacific Reef, both near Elliott Key, 22 miles south of Miami; at a reef off Miami Beach near a sewage outfall; and at "The Elbow," off Key Largo just south of Pennekamp State Park. Occupants of EDALHAB, a student-designed University of New Hampshire chamber, depended for life support on LULU, operated by the Woods Hole Oceanographic Institution. LULU carried the habitat from one location to another between dives.

The first FLARE operation began at daybreak on January 27, when LULU carried the 20-ton EDALHAB to the designated site at Long Reef, off Elliott Key. Moorings were installed despite threatening weather, and the habitat and the first team of aquanauts were in the water late in the day. For the next four days, marine biologists William

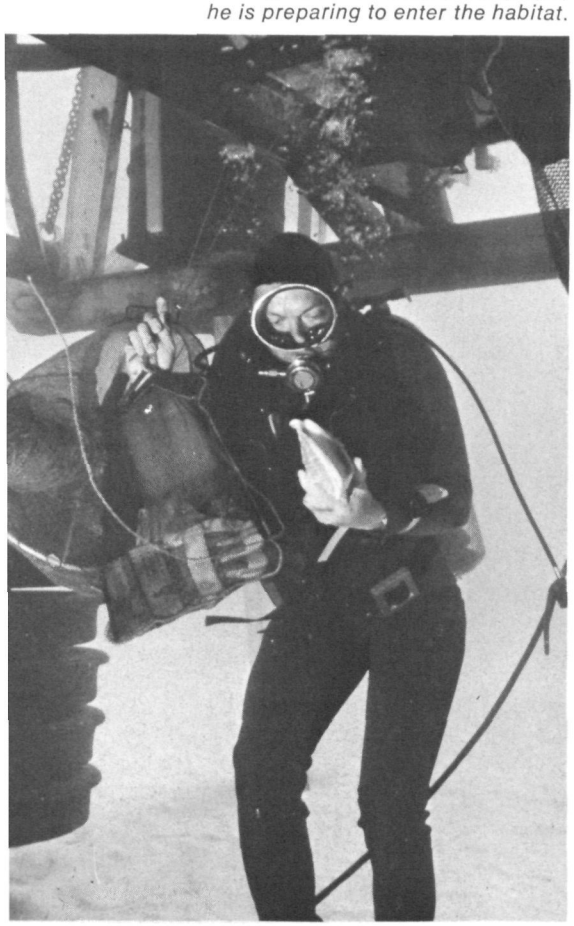
continued





(Opposite page) An artist's conception of the catamaran LULU serving as mother ship for the undersea habitat EDALHAB II, as they worked together on Project FLARE. (Above) The four sites for scientific research during the three-month project: a reef off Miami Beach; "The Elbow" off Key Largo; Long Reef; and Pacific Reef. (Right) J. Gifford, S. Cawthon, and E. Frehsee sit atop EDALHAB awaiting the start of their study of coral reef geology.

(Above) A team of FLARE divers exploring 50 feet below the sea surface. (Below) Ian Ellis, a marine biologist with the National Marine Fisheries Service, participated in the first dive, a study of the reaction of fish to trapping and holding devices. In the photograph, he is preparing to enter the habitat.



High and Ian E. Ellis, and ocean engineer Gary Loverich, all from NOAA's National Marine Fisheries Service Center at Seattle, Wash., observed at close range the behavior and reactions of different species of fish to trapping and holding devices the trio had installed on the seafloor. Their research centered on traps used by commercial fishermen, and was an extension of a long-term experimental program begun several years ago at the Seattle Center. The parent program was augmented by data collected by High and Ellis during the 1969-70 undersea TEKTITE project off the Virgin Islands, and from the HYDRO-LAB off the Bahama Banks last year in an earlier MUS&T project.

At the close of their dive, the team reported sighting a great profusion of marine life at the reef and said they had trapped—and released—a large number of reef fish in a relatively short time. Four six-foot-long, boxlike traps made of two-inch green nylon mesh were used for the tests, and were set out at intervals three feet above the coral bottom. Passing fish attracted to the bait—small living fish encased in small cages, and chopped fish—swam into the traps through a narrow, funnel-shaped entrance. Earlier tests disclosed that each of the traps can capture and hold as much as 1,000 pounds of fish, and that the mesh is strong enough to withstand the struggles of a five-foot shark. The team said the data collected would round out their research project and contribute substantially to the extensive literature they plan to publish on the subject in the near future.

The first of a two-part mission was undertaken February 6-10 by University of North Carolina marine physiologist Dr. J. Morgan Wells and his wife Anna, an oceanographer. They sought to analyze in precise detail the makeup of an uncontaminated coral reef and fix a pattern of metabolic rates against which the "state of health" of a reef under the influence of manmade pollutants could be measured, a week later. Dr. Wells is a veteran explorer of coral reefs in many parts of the world and well known as an expert on blood functions under pressure; his wife is an instructor in oceanography and a former diver-oceanographer for the Navy. The couple met while both were working on TEKTITE II in 1970. Assisting the Wellses at the surface was William Greeman, supervisor of the Laboratory of Hyperbaric Medicine at Duke University.

Among the many devices used during this unprecedented study, based on a comparison of the "community metabolism" of two reefs, were six plastic domes (8 inches to 4 feet in diameter), which were placed over portions of the living reef and sealed. Once in place, the domes had the effect of isolating separate coral communities. Instruments on the outside of the domes recorded oxygen, light, and temperature conditions within the enclosures. The domes automatically ventilated when oxygen levels became too high or to low, much as a house thermostat controls temperature. On the basis of the measurements obtained, the Wellses were able to calculate photosynthesis and respiration rates (community metabolism).

The Wellses also gathered further particulars about a phenomenon they call a "highly efficient recycling system" present in reef communities. The system begins with microscopic plants (about the same size as human red-blood cells) that live inside coral growths. These plants utilize waste products of coral to produce, by photosynthesis, soluble food materials that, in turn, nourish both the host corals and the plants themselves.

While the reef examined did not seem to support as much marine life as that found on similar reefs, Dr. Wells observed, its community metabolism seemed comparable to that of Pacific and Caribbean reefs.

Upon completion of their dive, the Wellses became the first American married scientists to live and work under saturated conditions in U.S. waters.

Coral reef geology was the subject of a FLARE project that had to be bobtailed because of severe weather. The team consisted of graduate geology student John A. Gifford and technician Stephen Cawthon—under the direction of their professor, Dr. Cesare Emiliani of the Rosenstiel School of Marine and Atmospheric Science, University of Miami—and underwater photographer Eric Frehsee. The trio submerged February 14, and immediately began the mechanical removal of large quantities of sand from a natural channel in the fore-reef through use of an airlift powered by a high-volume, low-presure compressor (a vacuum-cleaner, in effect). The hydraulic drilling unit and the airlift pump were donated and installed by the Marine Science Technology Department of Miami-Dade Junior College; the University of Miami Sea Grant Program also contributed support.

Once sand was removed and the bottom exposed, a core of the channel was taken by the hydraulic drill, which was equipped with a diamond corer. The apparatus made it possible for the aquanauts to obtain a long core, to six feet under the hard-rock face of the seafloor at the drilling rate of an inch per hour.

Team leader Gifford explained that the FLARE experiment was an extension of another study completed in early 1971 at Discovery Bay, Jamaica, in which geological samples and data were gathered from coral reefs. Cores from each location were to be compared, to see if the growth rates of coral reefs in widely separated areas of subtropical seas are alike or dissimilar. Initial observations at the Elliott Key site, Gifford said, suggested that the rates of growth seemed different, and that close analysis may reveal a contrasting evolutionary pattern.

In conversation after they had emerged from decompression on February 17, the aquanaut geologists said they saw distinct evidence of great shrinkage of the reef under study in both size and animal populations, due to natural evolutionary processes.

"Sea levels changed following the Ice Age," said Gifford. "This reef was probably under only five or ten feet of water several thousand years ago, but now it's in 50 feet.

In other words, its water cover has risen over the years. And since the viability of a coral reef depends heavily on sunlight for healthy reproduction rates, and light is decreased in direct ratio to depth, undoubtedly the changes we saw can be related to the higher sea levels."

While participants were still in the decompression chamber aboard LULU, FLARE personnel retrieved the EDALHAB and steamed north 22 miles to the next site, slightly north of Government Cut, on a line parallel to Miami Beach. Special equipment was installed on the seafloor at the new site, and the second half of the Wells project began.

Underwater participants in this phase were Dr. J. Morgan Wells, team leader of the first phase, and marine biologist John D. VanDerwalker, until this dive the MUS&T topside scientific coordinator of all earlier missions. Mrs. Anna Wells provided assistance to the aquanauts from the LULU.

The two researchers worked with the same ecology-measuring apparatus used earlier by the Wellses, but with far different results. Among their findings: The Miami Beach reef apparently loses uncountable amounts of energy because of clouds of siltation in the upper layers of water, which prevent penetration of essential sunlight ("like putting a blanket over a cornfield," said Dr. Wells); the reef is nearly colorless ("looks like the bleached coral you find in souvenir shops," said Mr. VanDerwalker) and almost devoid of the algae that nourishes coral life; large, dead portions of the reef probably expired as recently as the last decade; the marine inhabitants differ markedly in species composition from those usually found in and around coral reefs; and almost no juvenile fish were present, only adults.

In short, the aquanauts said, the reef appeared deteriorated but not dead, and the reef ecosystem is dramatically different from that of other reefs in Florida and elsewhere in the world. Dr. Wells said that even a preliminary comparison of the Miami Beach reef with Long Reef left no doubt that the two reefs differ in almost every characteristic. He said he had seen reefs "in worse shape," such as those off Micronesia that were devastated by the crown-of-thorns starfish and totally dead to outward appearances, but the Miami Beach reef was unique in both physical appearance and strange ecosystem.

"In places where we were able to detect signs of recovery in the Micronesian reefs," Wells said, "the established life pattern of the reef was simply resumed. A new system did not evolve to replace the old one."

The FLARE scientists gave the following explanation of the contrasting ecosystems:

In a natural, uncontaminated reef, a remarkably efficient "recycling" process keeps the reef alive and well. The system begins with microscopic plants that live inside coral growths (symbiotic algae), and convert waste products of coral—by photosynthesis—into soluble food materials. Food so produced nourishes both the host corals and the plants themselves. A natural healthy reef is, there-

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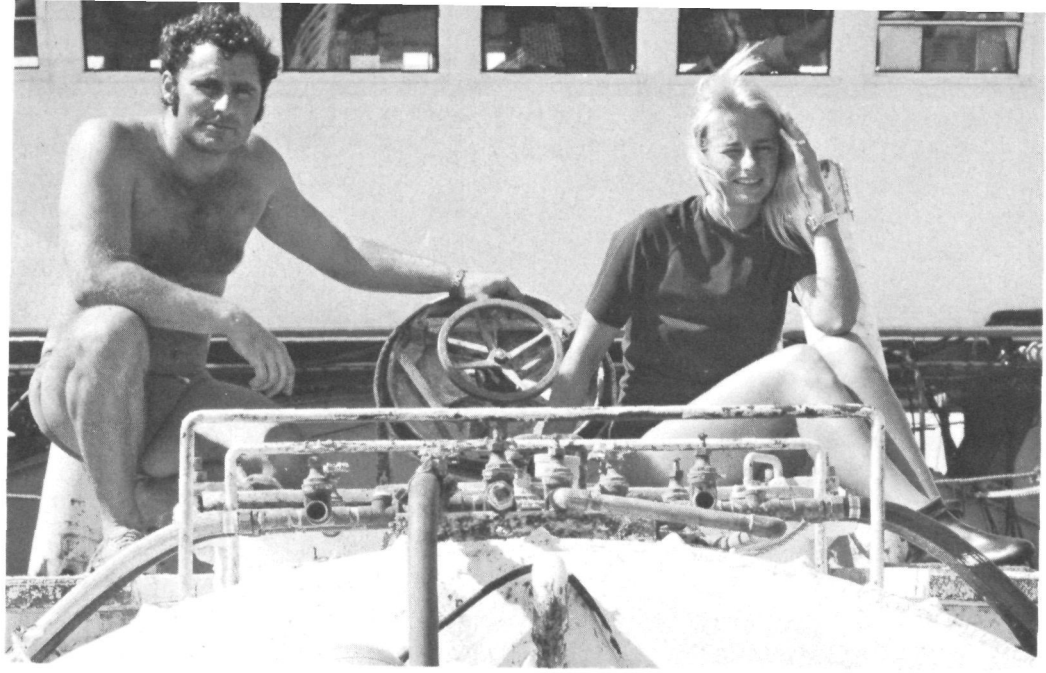
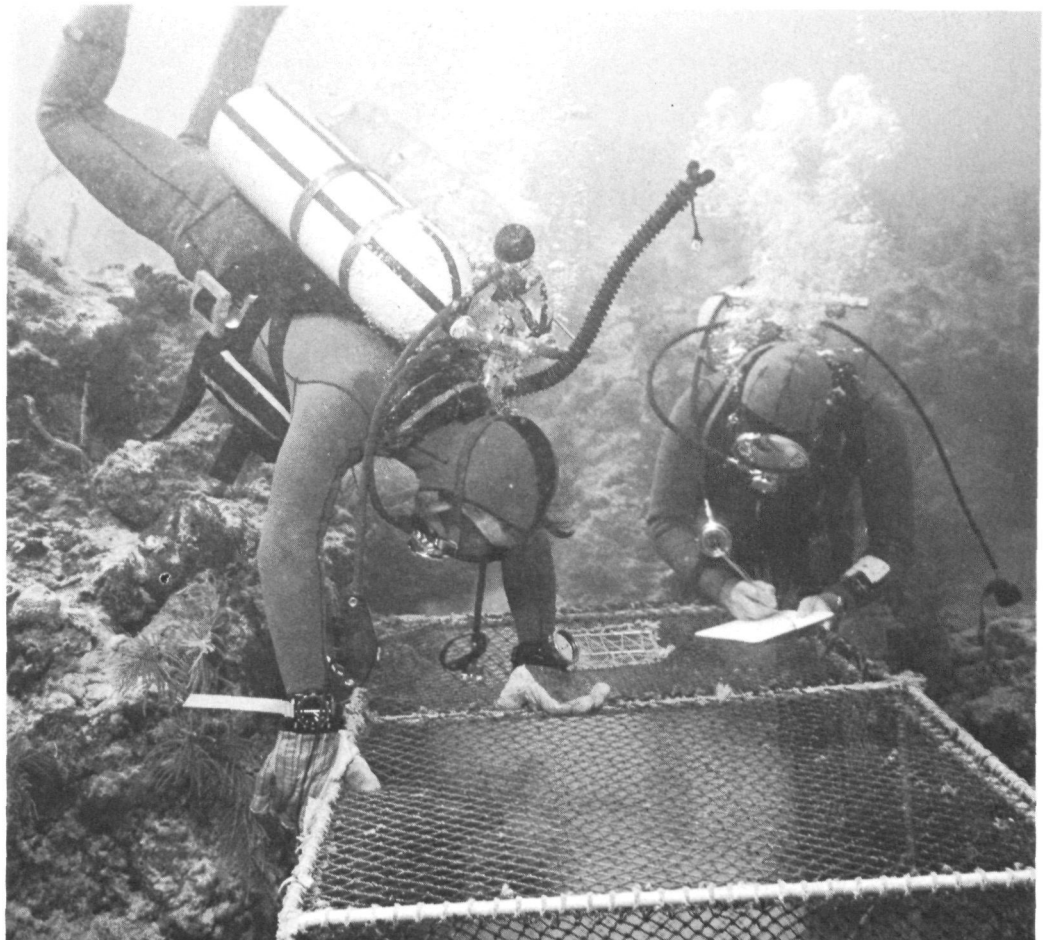
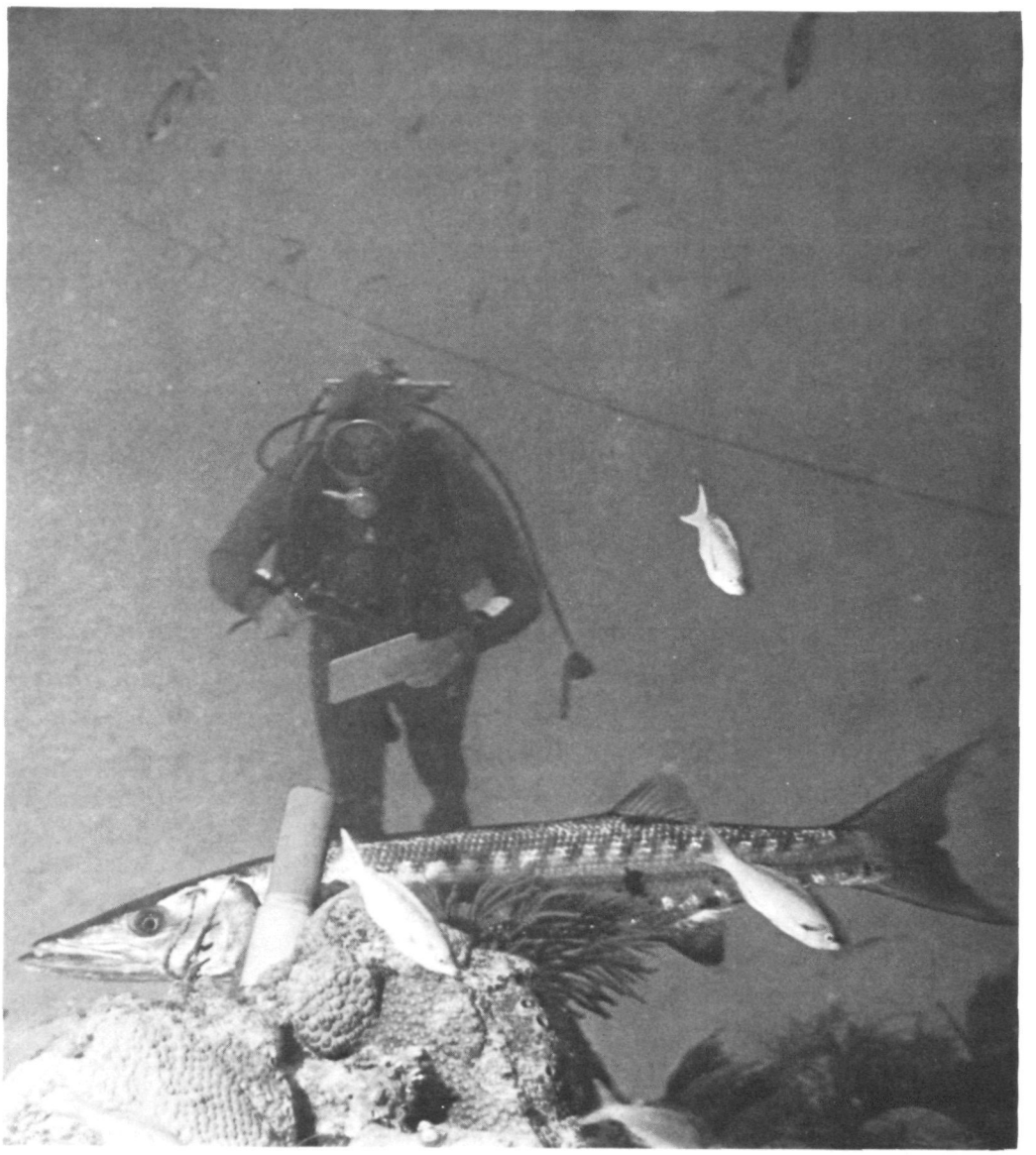


(Above) Dr. J. Morgan Wells and his wife, Anna, compared the ecology of contaminated and uncontaminated reefs. Upon completion of their dive, they became the first American married scientists to live and work under saturated conditions in U.S. waters. (Left) EDALHAB in place on the sea floor. (Below) NMFS diver-scientists William High and Ian Ellis monitor specially designed fish traps used in the first dive.





(Above) Diver scientist investigates the artificial reef, made of some 500 discarded rubber tires, which was compared with a natural reef to determine whether manmade reefs assume the same characteristics as natural ones. (Left) A barracuda glides past NMFS scientist William High. (Below) A parrotfish and two huge sponges at "The Elbow" site, where the diving team of three women reported a profusion of gigantic sponges.

fore, a self-sufficient and stable community.

The Miami Beach reef, on the other hand, apparently runs on a different system—only a few patches of algal growth were seen; on the basis of visual observations of the "bleached" appearance of much of the coral, photosynthesis is at a very low rate or completely absent; measuring instruments recorded no production of oxygen; the rate of production of nutrition within the measuring domes was less than the rate of consumption; and the organisms in the reef (feather-duster worms, sea whips, Gorgonians, and the like) were almost all "grabber" or filter feeders, dependent on the water column for existence.

Does the outflow of human sewage at the FLARE site produce lethal effects on underlying reefs? The scientists feel that the raw sewage is probably a minor part of the massive amounts of sediment that cloud the water, bringing about lower rates of photosynthesis and possibly alterations in the character of the coral community. Sewage, runoff from dredging and construction, turbid bay water flowing into the area, and natural runoff all combine to produce dirty water, they said.

"We found light levels to be less than half what they were over the reef examined earlier—and our Miami Beach readings were taken on days when the water was as clear as it had been any time during the previous six months," said Dr. Wells. "Maybe this Miami Beach reef can somehow survive in such a potentially deadly environment, maybe not. Certainly it must be put on the 'critical list'. When analyzed, our data may make possible a more precise prognosis."

Mr. VanDerwalker added: "There may be an adaptation factor at work on a reef such as this, which brings about a change in its basic character and allows it to survive in an adverse environment. We need to spend much more time and study on just such phenomena before we can even *begin* to understand these subjects."

Biologist VanDerwalker also said he was surprised at the composition of the fish populations around the reef. Few of the ordinarily abundant parrotfish and other reef dwellers were seen; one species of damselfish outnumbered the several other species by about a hundred to one; small lobsters were present in large numbers—many more, VanDerwalker said, then he saw in commercial grounds around the Virgin Islands; juvenile fish were missing; and extremely large barracuda crowded the area.

Both aquanauts observed a minor behavioral peculiarity among the barracuda, apparently triggered by the whirring noise made by the underwater propulsion devices (sea scooters) used to cruise over the reef. The ordinarily reserved and cautious barracuda became frantically excited by the sound and chased close behind the divers' swim fins with mouths wide open and teeth snapping audibly. Except for that one adverse effect, the divers were greatly impressed with the versatility and efficiency of the sea scooters, which they were using for the first time.

Immediately after gear had been retrieved from the seafloor and the divers released from the decompression chamber, LULU picked up EDALHAB and the two were off again. Destination: Pacific Reef in the upper Florida Keys, where in late January FLARE workers had set down an artificial reef.

NOAA's National Marine Fisheries Laboratories at Narragansett (R.I.) and Boothbay Harbor (Maine) provided marine biologists Harold L. Pratt and Kenneth Pecci and marine technician Clifford Newell for this four-day study, the first of two missions. The reef which covered 646 square feet, was made of some 500 discarded rubber tires.

The experiment marked the first time an artificial reef had been built virtually beside a natural reef, and designed to conform closely in configuration and environmental aspects to an authentic one. The tires were scattered and piled in the selected area in 20 stacks of four to eight tires, fastened together with steel rods run through the stacks. Each stack was weighted with concrete test cylinders placed in the circumference of the bottom tires, causing it to come to rest in an upright position on the bottom. Stacks were arranged in heaps, giving a naturally irregular appearance, in 45 feet of water, with a few single tires randomly distributed. This type of structure has proved highly successful in a number of experiments in other areas. The worn-out tires are cheap, almost indestructible, and make excellent bases on which marine life can grow. The hard, convoluted surfaces are ideal for concentrations of algae and encrusting organisms, and for small fish that find food and shelter in the many holes and crevices in and around the stacks. Larger predatory fish gather around the newly formed "fish havens," as do crustaceans and mollusks.

The main thrust of the two-part survey, said team leader Pratt, was to conduct a close and uninterrupted comparison of the two kinds of reefs—artificial and natural—to ascertain whether manmade reefs took on the same characteristics as natural structures, and how fast the evolution took place.

The aquanauts found that the new reef showed every sign of becoming a brand new marine community. Their report supported the belief that first young fish, then adults, migrate rapidly into new habitats if environmental conditions are favorable. They said the artificial reef was full of one- to three-inch juvenile specimens of reef fish—grunts, parrotfish, damselfish, wrasses, drums, hogfish, tomtates, and hamlets—which were occupying home grounds in and around the algae-covered tires. No adults and few predatory fish were yet permanent residents.

In essence, findings were that the reef had grown as anticipated; fish families present were virtually the same as those on the nearby natural reef, but consisted of a new—not a displaced—population; and a fine film of algae, excellent for grazing fish, had covered the artificial reef. Counts of all inhabitants of both reefs, by numbers and species (to be verified on the second inspection), indicated whether they were "transients" or full-time residents of each reef.

The team agreed that the use of EDALHAB permitted them to become "part of the scenery, not intruders," and thus obtain a

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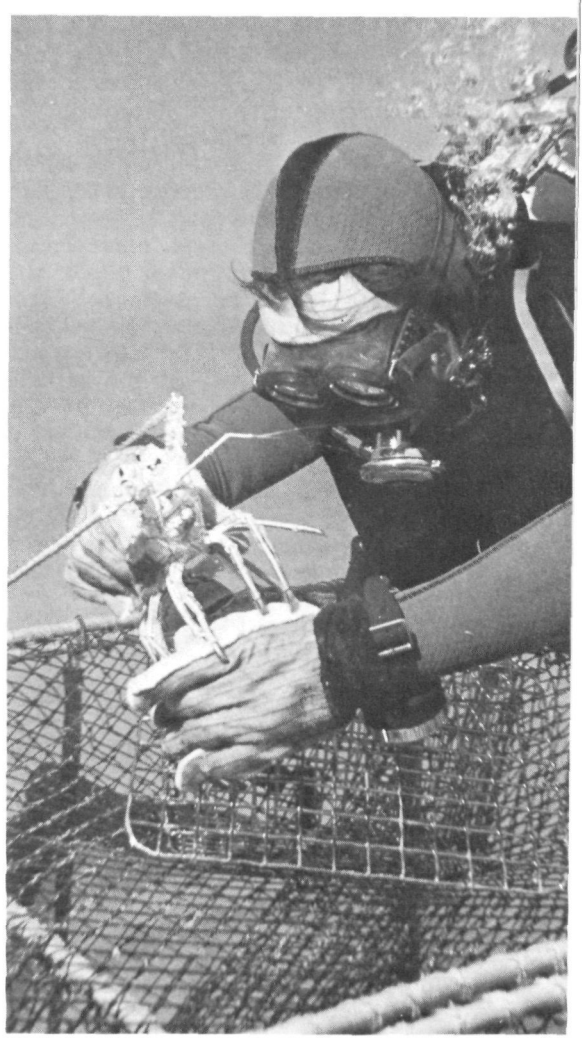
(Above) An NMFS team found that 30 species of fish had been attracted to the artificial reef established in Florida's Biscayne National Monument. The reef's fish population will be monitored regularly in future. (Below) Releasing a prisoner of the NMFS fish-trap experiment.



close and intimate view of the life around them.

"For instance," said technician Newell, "we were able closely and repeatedly to observe a 'cleaning station,' at which a three-inch-long French angelfish living in a clump of coral was regularly visited by 12-inch-long jacks, to be picked clean of parasites. When the jacks came to the obviously long-established station, they would slow down and swim around slowly, awaiting their turn to be cleaned. And many of the fish grew so accustomed to our presence that they would unhesitatingly eat food out of our hands."

Marine biologist Pratt said he expected to find an increase in population on the second phase of the study in mid-April. Drawing on past experience, he said that an artificial reef will surpass a natural one in fish populations during its first couple of years, then stabilize; also that an artificial reef is not considered "seasoned," in the sense of having attracted all natural reef inhabitants, until it has been established for about four months.

The LULU and EDALHAB returned to Miami from the Elliott Key site in early March to enter a shipyard for a three-week period of overhaul. Phase II of FLARE then began, at a new site called "The Elbow" off Key Largo, on the southern border of Pennekamp State Park, Florida. In the first dive, three women aquanauts studied undersea plant life and its significance to marine animals. They were botanist-biologist Dr. Sylvia Earle, a member of the staff of the Los Angeles Museum of Natural History and the mother of six children; botanist Carole Aregood, a biology teacher at Trenton State College, N.J.; and diver-engineer Zdenka Goldstein, working toward her engineering degree at Miami-Dade Junior College.

Collectively, the three women have had many years of diving experience off both coasts of the United States, in the Caribbean, off South America, and in the Indian Ocean. Dr. Earle was team leader on one of the 1970 TEKTITE II missions off the Virgin Islands, a participant in dives on the submersible DEEP DIVER off the Bahamas and in the 1968 "Man-in-the-Sea" project. She was selected in 1970 as the Los Angeles Times' "Woman of the Year."

Dr. Earle and Ms. Goldstein dived repeatedly at the new site for three days preceding their project, then submerged on March 28 to spend four days living in and working from the EDALHAB, which was as usual anchored at a 45-foot depth. Ms. Aregood remained aboard the LULU to collect botanical specimens in shallow-water dives.

After the mission had ended, the aquanauts reported seeing impressive numbers of reef fish, but an almost total lack of food fish (for humans), such as groupers and snappers ("probably due to heavy fishing pressure at that particular reef"); a great variety of heavily grazed coral plants ("we gathered more than 100 species"); spectacular numbers of squid and cuttlefish at night; dozens of curiously diseased fishes ("they were ragged and spotty looking"); and a striking number of gigantic sponges of non-commercial type ("we never saw sponges in greater profusion anywhere else in the world").

Team leader Dr. Earle said that visibility was good during her dive with little siltation in the water, possible—she thought—because of the strong currents at the site. She was puzzled by the diseased fishes observed, and said she had never before come upon that manifestation on any other reef.

"We saw many damselfish obviously infected with what could have been a fungus disease, and Carole saw some angelfish behaving peculiarly—swimming on their sides," said Dr. Earle. "Perhaps we were seeing some rare disease. Or perhaps the community balance at the reef is somewhat disoriented by the lack of predatory fishes, which usually consume weak or damaged specimens."

Dr. Earle was pleased with the large collection of deepwater living plants she obtained, which she plans to cultivate for the first time in a laboratory. Little is known, she said, about the reproductive cycles of marine plants, and about the ultimate depth at which such plants may grow. Knowledge of pigmentation in living and freshly preserved vegetation is expected to cast new light on the subject.

The principals in the following dive were interested in another aspect of plant life—the relation between climate and periodic increases or decreases in quantities of seaweed present in subtropical waters, and in identifying species inhabiting temperate, subtropical, and tropical Atlantic waters. Dr. Arthur C. Mathieson, an associate professor at the University of New Hampshire and a visiting research scientist at the University of South Florida, and two of his graduate students (at UNH), Richard Fralick and Barry Hutchinson, occupied EDALHAB while undergraduate student David Drew assisted from aboard the LULU. Dr. Mathieson has been engaged in studies of seaweeds for some time in the Florida Keys and on an earlier TEKTITE II project (with Mr. Fralick) off the Virgin Islands.

Scientific understanding of seaweed populations is of value not only to marine ecology, but to the food and drug industries, Dr. Mathieson said. Seaweed forms a nursery ground for young marine specimens and is an important habitat for invertebrates and small fishes on which adults of many commercial and sport fish feed. Nutrients released into the sea as seaweed disintegrates are essential elements in the oceanic food chain, since they provide forage for plankton and bottom-dwelling plants and animals. Moreover, ingredients obtained from seaweed are used in a great variety of products, including toothpaste, cosmetics, paint, dietetic foods, jellies, soft drinks, and desserts.

The three botanists said that, from their point of view, the vegetation they saw on the reef was in a healthy, undamaged state. They pointed out that the high diversity of plant species observed, though heavily grazed by herbivorous fishes, indicated a well-balanced community unaffected by pollution or siltation. Dr. Mathieson said that the reef's condition was in dramatic contrast to closer-to-shore regions he had observed along the Florida coast, in which siltation from dredging had caused stunning damage in the form of "a slimy, gummy layer of material covering the reefs." The aquanauts collected seaweed from assorted substrate—reefs, sandbanks, and rocky areas—for later quantitative evaluations of distribution and abundance, obtained data on the feeding habits of plant-eating fishes and echinoderms associated with seaweeds, and studied food preferences of sea urchins.

Ichthyologists Dr. C. Lavett Smith of the American Museum of Natural History (New York City), and Dr. James C. Tyler of the Academy of Natural Sciences (Philadelphia) took a four-day fish census of residents and visitors occupying a 30-square-foot portion of "The Elbow," in which a number of coral heads were located. Both men have explored similar subjects as aquanauts on TEKTITE II and in many other regions of the world ocean. Their FLARE work represented an elaboration of earlier research. Dr. Smith is the author of a recently published book, "The Hidden Sea."

Drs. Smith and Tyler explained the course their several years of research is taking by theorizing that population densities, in relation to the amount of available space on a reef, have a regulating effect on the number of individual fish that can be accepted in a community. Past studies have shown, they said, that each species living on a reef has evolved in conjunction with its neighbors to fill a highly specilalized role in the community. Thus the community structure is both the result of, and the setting for, the evolutionary processes: Drs. Smith and Tyler said that each species in a reef community has its own special food and hunting requirements—some species eat large fish, some eat small fish; some eat worms and vegetation, while others eat only other fish; some are active in hunting and feeding at night and others in the daytime. One group of fishes feeds only in loose sand and others graze on rocky bottoms. Some hide among corals and others dig burrows in the sand. Often the timing of reproduction is staggered so that space and other breeding needs are reduced. Symbiosis (an association of species advantageous to all members) is important—some fishes obtain food by cleaning parasites from others, some live among and resemble live corals, and still others reside in living sponges. On the whole, a coral reef embodies a self-regulating, self-sustained community. Dr. Smith said that this type of research is of interest to the broad study of the evolutionary development of specializations and adaptations.

At the end of their expedition, the ichthyologists reported that the reef under study seemed in excellent health and alive with 77 species of fish. They said that "The Elbow" appeared comparable in all respects to similar reefs they had monitored in Bahamian and other tropical waters. About 12 species made up the permanent reef

community, and about 15 transient species passed through repeatedly. The pair saw the predictable kinds of reef grazers, and counted a number of carnivorous types such as barracuda, four kinds of grouper, hogfish, and snappers. Dr. Smith said—as did a number of earlier FLARE divers—that they were impressed by the extraordinary size and coloration of the large numbers of angelfish on the reef.

Noting that some of their observations were slightly at odds with earlier ones, Dr. Smith said the discrepancies between findings only served to underscore the value of the FLARE concept. He said that since monitoring of reefs is still in beginning stages, scientists cannot yet judge with much accuracy whether a reef is healthy or defective, particularly over widely separated areas. Long-term and repeated visual observations of many reefs is a vital need at this point in history, he said, since coral reefs—which contain large numbers of sessile organisms (those that remain in relatively fixed positions)—are particularly vulnerable to alterations in their environment.

On April 12, the LULU headed north to Pacific Reef, occupied on one earlier expedition, and sent the last FLARE team below on the following day. The team leader, Harold L. Pratt was to monitor the artificial reef set down in January for FLARE experiments. He was accompanied by another marine biologist, Frank W. Steimle, Jr. from NOAA's National Marine Fisheries Laboratory at Narragansett, and by technician Roger Clifford from NOAA's Boothbay Harbor laboratory. In an advisory capacity aboard LULU was artificial reef expert Richard B. Stone of the NOAA Atlantic Estuarine Fisheries Center, Beaufort, N.C., who made frequent dives down to EDALHAB to consult with his coworkers during the four-day examination of the young reef.

Using the biological "blueprint" acquired on the first artificial reef mission, the aquanauts considered production rates of marine animal life. On the earlier exploration, the aquanauts had found the beginnings of a resident population consisting of quantities of juvenile reef fishes, but no adults and no large predators. This time they spotted a number of adult fish occupying apparently permanent quarters, including two-to-three-foot-long hogfish, and parrotfish weighing an estimated 40 pounds each. Visitors to the reef included mangrove snappers, a valued sport catch. In all, the NOAA team counted an additional eight to ten species in the new marine community, bringing the total to some 30 species.

Florida's Biscayne National Monument, in which the experimental reef lies, gave NOAA permission to let the artificial reef remain within its boundaries after FLARE had ended. Surveillance of the structure will be on a four-times-a-year basis from now on, under the direction of marine scientists from NOAA's National Marine Fisheries Service sport fishery program. A

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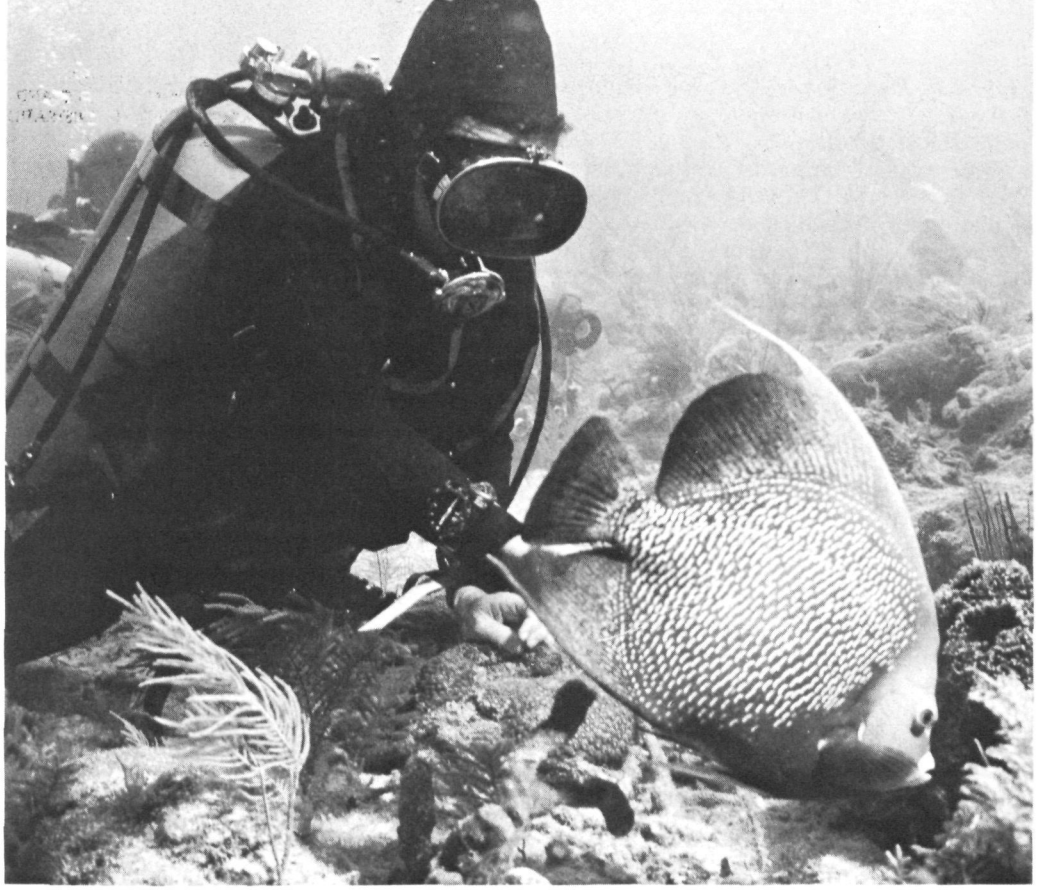
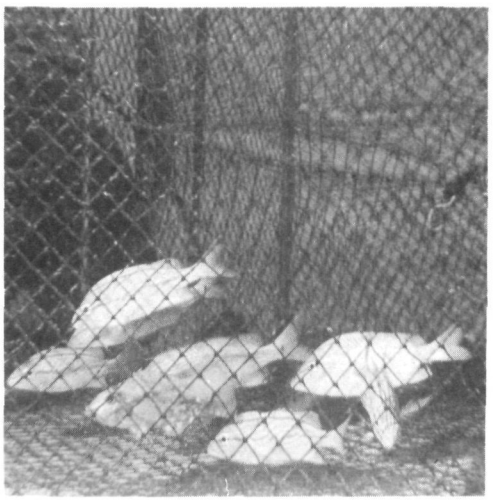
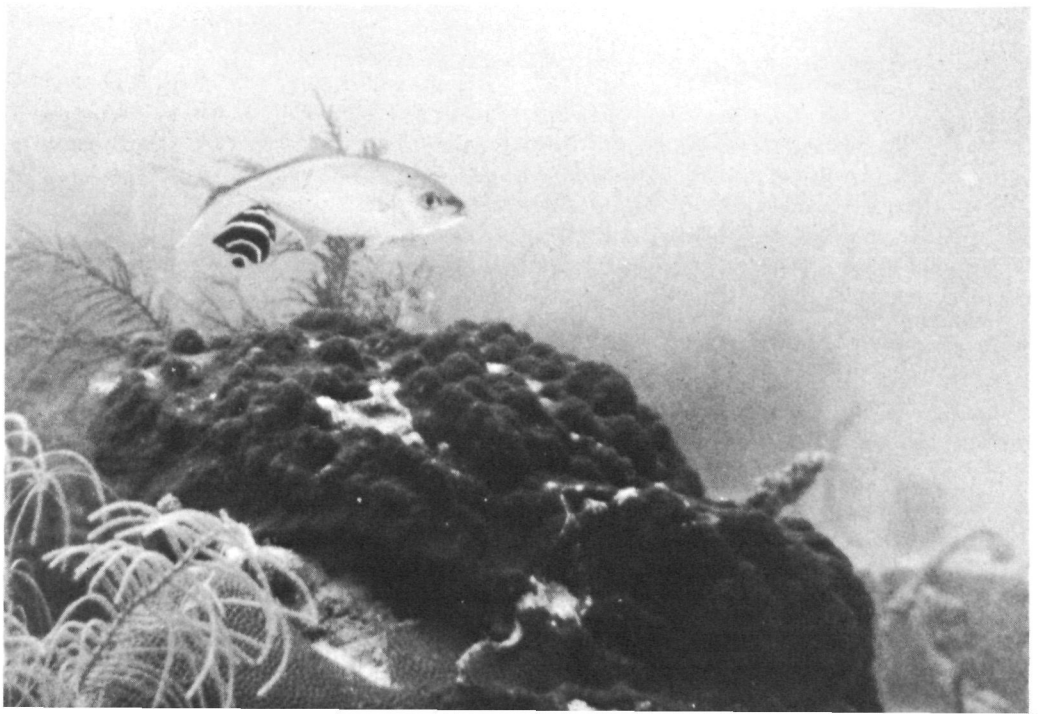




(Above) Dr. Sylvia Earle watches a French angelfish eating marine plants, during a project at "The Elbow." (Left) Fish in NMFS traps. (Below) Studying natural and artificial reefs, NMFS scientists were able to observe a "cleaning station," where a three-inch-long angelfish living in a clump of coral was regularly visited by 12-inch-long jacks, to be picked clean of parasites.



National Park Service marine biologist, Gary E. Davis, will monitor the site at more frequent intervals.

Several other scientific research efforts used the LULU-EDALHAB combination as a platform from which to conduct adjunct experiments in meteorology, physiology, and underwater communications.

Each day, technicians Monty Poindexter and Richard Rutkowsky of NOAA's Sea Air Interaction Laboratory (part of the Atlantic Oceanographic and Meteorological Laboratories, Miami) took regular "radiation profiles"—measurements of solar radiation penetrating the sea from surface to the 45-foot depth. Several automatic devices installed aboard the LULU made hour-by-hour measurements. FLARE research was part of a broader program that seeks to establish, through repeated broadscale investigations, a "norm" for amounts of sunlight that annually enter tropical and subtropical waters—to culminate eventually in a kind of extremely extended prediction of solar radiation annually.

On selected dives, physiologist Allan Waterfield and bioengineer Roger Fall, both on the teaching staff at the University of New Hampshire, used telemetry systems to measure physiological changes in divers at different depths and intervals. The telemetry system, which was originated by Dr. H. R. Skutt, professor of electrical engineering at the university, and used on such diverse organisms as rats, deer, and trees, measures heartbeat rates and skin and internal temperatures at varying depths. The aquanauts being tested wore electrodes (like those used in electrocardiographs) and plastic probes to provide data on their efficiency over extended periods in a "saturated" state. Measurements were transmitted to the LULU by a sonar device (no wires) carried by the diver/scientists. The investigators, who were joined by Dr. Skutt for one day aboard LULU, said that some of their data collected from FLARE divers indicated that after three days underwater, the body begins to lose heat at an accelerated rate. Other findings from FLARE will be announced after analyses have been completed at the University of New Hampshire.

In another study, University of Florida scientists experimented with communications systems in an effort to determine how the efficiency of underwater work might be improved through better communication among divers. Work was directed by Dr. Howard Rothman, with the assistance of Dr. Steve Feinstein and two Marine Corps officers, Major William Bond and Capt. Michael Hyatt. Testing involved one-hour periods in which a team of divers assembled a framework of plastic pipe underwater, once with and once without communication equipment. Details of the tests were observed by Dr. Rothman in the water and tape recorded, to become part of a long-term study of the effect of communications on divers by the University of Florida.

Work during the entire three months of FLARE was directed from the LULU by program coordinator William Rainnie, operations coordinator Barrie Walden, and Capt. Dale Butler, all from the Woods Hole Oceanographic Institution. Dr. Godfrey Savage of the Universiy of New Hampshire was the habitat engineer. (The EDALHAB was constructed, then modified, by students in Dr. Savage's Engineering Design and Analysis Laboratory, from which her name is derived.)

The nine scientific missions completed on FLARE were directed, during separate intervals, by former MUS&T marine biologist John G. VanDerwalker and by MUS&T marine geologist Dr. Robert F. Dill. Other MUS&T participants handling contracting and liaison duties in Miami were Elliott Finkle, William Hamilton, and Commander Robert Nevin, USN, assigned to MUS&T.

By the time FLARE closed, all votes were counted and the message was clear from those most concerned, the diver-scientists. To the question first propounded by MUS&T when FLARE was in planning stages—"Is a portable habitat a feasible platform from which to launch underwater scientific investigations of long duration?"—the answer was most emphatically yes. One aquanaut after another confirmed the favorable verdict:

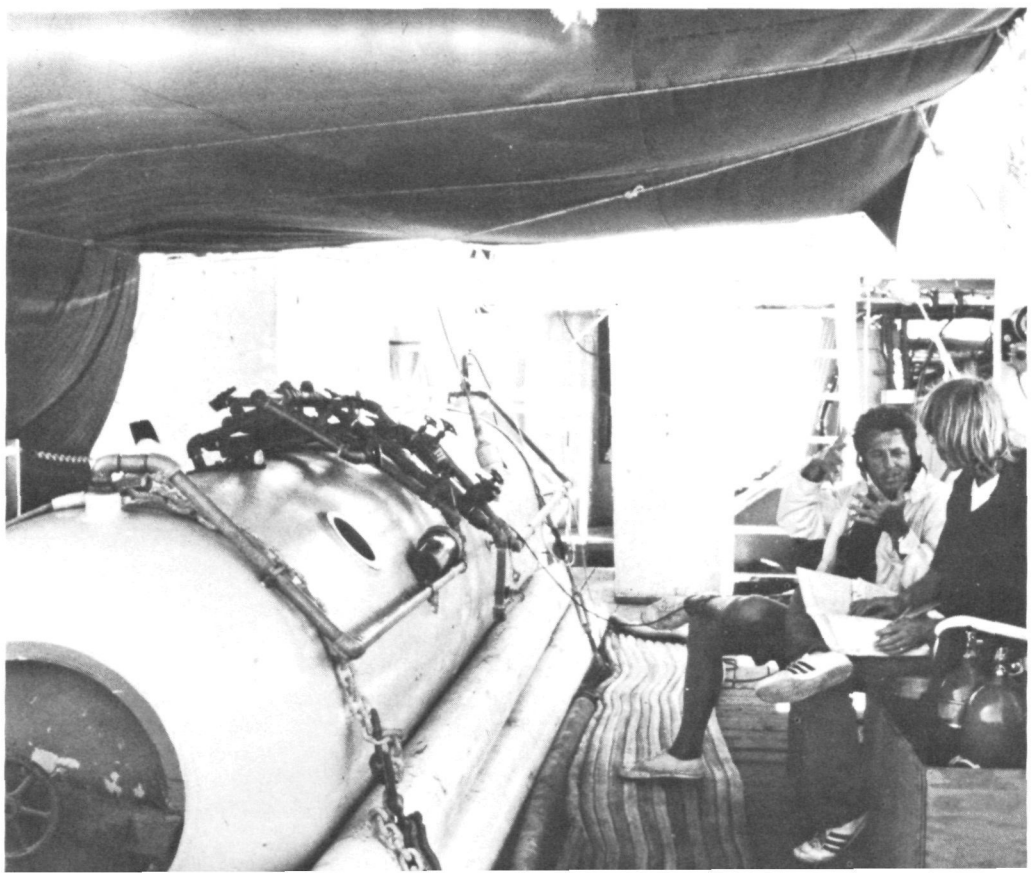
". . . an indispensable platform for our fish observations."

". . . able to accomplish at least twice as much uninterrupted work as would have been possible from surface operations."

". . . an opportunity to study sea life in a classroom underwater and observe real-life specimens seen heretofore only in textbooks."

Perhaps the most telling comment was made by scientific coordinator John VanDerwalker, who said: "The LULU-EDALHAB approach helped us prove a point. But we need all kinds of such vehicles—large, fixed undersea laboratories, small ones such as HYDROLAB, submersibles such as the PC-8 and ALVIN, and more sophisticated versions of habitats like EDALHAB.

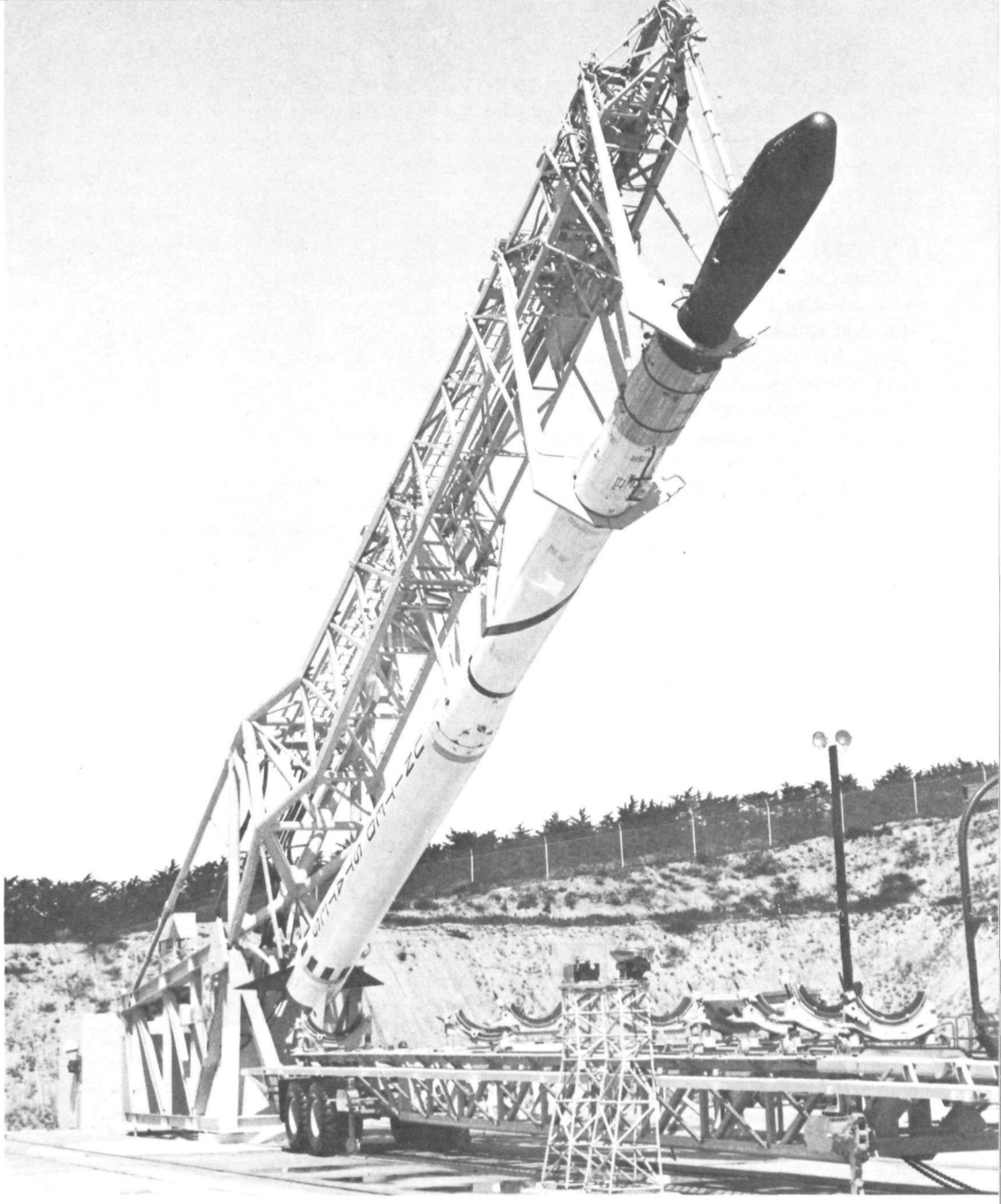
"I see the next big step in undersea exploration as the development of some combination of an EDALHAB-like platform with differing breathing mixtures and systems, so that scientific parties can dive to varying depths and prolong their excursions underwater." □



(Left) After four days on the sea floor, FLARE aquanauts spent 19 hours in the decompression chamber, as watchers monitored their condition. (Above) Diver-scientist Morgan Wells, draped with equipment for his reef ecology study.

Seven years of satellite data are signed, sealed, and delivered, so

topside sounder signs off



An ionosphere explorer satellite (Explorer XX) being raised into launching position at the Pacific Missile Range, California.

BY RALPH SEGMAN

"One of the things that makes this event so unusual is that we are finishing something."

This remark by Robert W. Knecht, Deputy Director of NOAA's Environmental Research Laboratories, was made just prior to the March 31 closing of the Space Environmental Laboratory's Topside Sounder telemetry station in Boulder, Colorado.

In operation since 1964 on Boulder's Gunbarrel Hill, the station acquired, processed, and distributed data from the six earth satellites of the Topside Sounder and International Satellites for Ionospheric Studies (ISIS) programs.

"So often, especially in research projects, the work goes on and on," Knecht said. "The Topside Sounder/ISIS program was not intended to be indefinitely long. It had specific objectives. And judging from the papers and reports that I have seen, most of these have been reached."

Broadly, the objectives of the program were to conduct a comprehensive synoptic study of the topside of the ionosphere during a complete range of solar activity, covering an entire solar cycle, and to provide the basis for a theoretical understanding of the observations.

Before 1957, when the first earth satellite was launched, measurements covered chiefly the bottomside of the ionosphere. At that time the main observational instrument was the ionosonde, a radar that receives electromagnetic echoes from the ionosphere. When low-frequency transmissions were used, the echoes returned from the lower regions of the ionosphere where the electron densities were low. Greater frequencies penetrated deeper into the ionosphere, the highest echo returns coming from the region of maximum electron density, which typically is located at about 300 kilometers altitude. Still greater frequency transmissions passed clear through the ionosphere without echoes, leaving the topside of the ionosphere virtually unexplored except for a number of intriguing sounding-rocket passes.

The concept of a joint topside sounding program involving Canada and the United States arose during the second half of the International Geophysical Year. As described by John E. Jackson of the National Aeronautics and Space Administration and E. S. Warren of the Canadian Communications Research Centre:

"One highlight of the IGY cooperation was the very successful U.S./Canadian rocket program conducted at Fort Churchill, Canada, which, in a sense, was a precursor to the present U.S./Canadian cooperation in space. The promises of space technology

continued

were strengthened even more during the IGY by the Sputnik and Explorer satellite launchings. It is therefore not surprising that the scientific and technical environment existing in 1958 led to the topside sounder concept essentially simultaneously in Canada, England, Germany, and the United States."

The history of topside sounding can be said to have begun in July 1958, when the Space Science Board of the U.S. National Academy of Sciences requested suggestions for satellite experiments. As a result of this request and a series of subsequent meetings, the U.S. and Canada announced a joint undertaking with each country paying its own costs. Canada supplied the satellite (Alouette 1) instrumentation and three telemetry stations, while the U.S. provided the launch vehicle.

NOAA's Environmental Research Laboratories came into the picture in early 1959, when NASA asked the Central Radio Propagation Laboratory (part of which later became ERL's Space Environmental Laboratory) of the National Bureau of Standards to examine topside sounder proposals it had received for scientific merit and engineering feasibility, and to recommend immediate and long-range research approaches. CRPL recommended a fixed-frequency sounding system to complement the Canadian's swept-frequency system. NASA accepted the recommendation and CRPL was given responsibility and funding for the program that later developed the Explorer 20 satellite.

Explorer 20 provided soundings that were essentially continuous in space at a series of discrete frequencies. By contrast, the Canadian Alouette 1 made soundings through a nearly continuous band of frequencies at a series of discrete locations.

While Explorer 20 was being designed and constructed, telemetry facilities were established at Gunbarrel Hill for taking data from Alouette 1 (orbited in September 1962) as well as from Explorer 20. The satellite was launched in August 1964, and a CRPL group under Wynne Calvert took control of the ionospheric topside sounder. This involved, in addition to data acquisition and processing, monitoring to keep up on the satellite's condition and preparing and distributing schedules based on Explorer 20's passes. For seeing the project through, from design and construction into the orbiting phase, the group was awarded the Department of Commerce Gold Medal in February 1965.

Under continued NASA funding, the telemetry station produced magnetic data tapes and filmed ionograms for the two existing space vehicles and for a series of later satellites: Alouette 2, Explorer 31, ISIS 1, and ISIS 2.

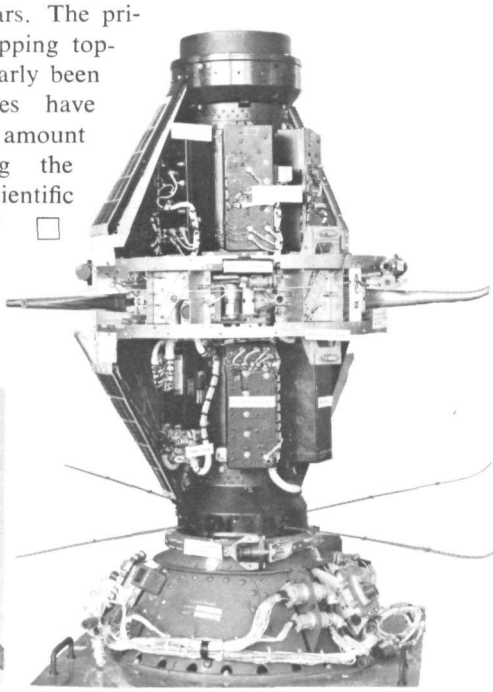
The demise of Explorer 20 is explained by Edward R. Schiffmacher, last chief of the SEL Off-Line Data Services Group: "Explorer 20 continued in good health until the winter of 1965-66, when due either to an internal failure or receipt of a spurious command, it latched on in a high-power mode. Before the condition could be corrected, the battery voltage dropped catastrophically low, and the high-power load could not be commanded off. The satellite became a weakly radiating derelict."

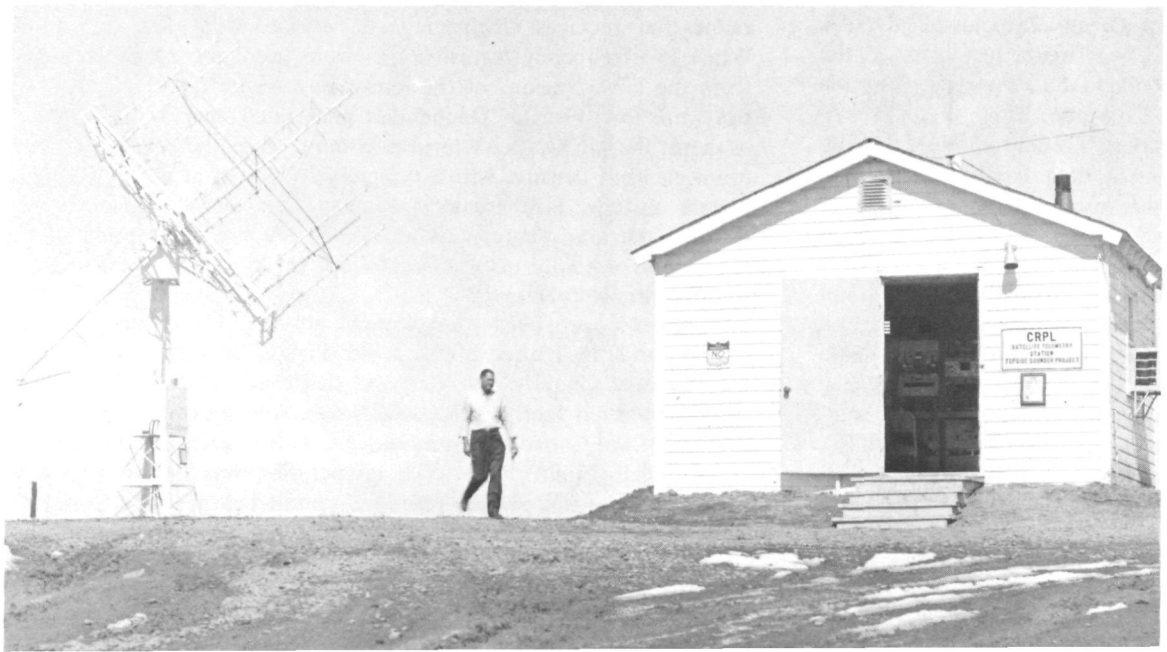
The satellite sounders revealed in great detail the structure and properties of the topside of the ionosphere in a relatively short time. They found that electron densities formed domes and ledges aligned with the earth's magnetic field. There are also troughs and ridges of electron density oriented in an east-west geomagnetic direction. Very long ducts were discovered that looped between the Northern and Southern Hemispheres; the ducts guide radio waves back and forth between hemispheres. The Topside Sounder scientists also have been able to observe the dynamic responses of the ionosphere to geomagnetic storms ignited by solar flares.

A great mass of data has been made available to the world scientific community by telemetry stations in the United States and Canada, and in other nations that later joined the program: the United Kingdom, Norway, France, India, Japan, New Zealand, and Australia. The NOAA station alone produced about 8,000 reels of processed magnetic tape, which weigh some 17 tons and which, if laid out full length, would stretch about 20 million feet. Nearly 130,000 filmed ionograms also came out of the prolific station.

There is a tremendous amount of information in these records, enough to keep scientists busy for years to come. Any qualified investigator may acquire topside soundings from World Data Center-A, operated by NOAA's Environmental Data Service in Boulder, and other similar centers in the U.S., USSR, Japan, and the U.K.

"Without doubt, certain aspects of the Topside Sounder/ISIS program will be continued by others for some time to come," said Knecht. "But I think we can all be proud of what was accomplished at the Boulder Labs over the last seven years. The primary objective, that of mapping topside electron density, has clearly been achieved. Many subtleties have been clarified. And a vast amount of data, surely containing the answers to many other scientific questions, has been collected." □





(Above) The Explorer 20 topside sounding satellite, launched in July 1964. (Left) The topside sounder telemetry site on Gunbarrel Hill in 1964, with station manager Leray La Baume.

NOAA Profile

Mrs. Fontaine (center) frequently demonstrates fish cookery on television programs.

Home economists from far and wide travel to Pascagoula, Mississippi, to learn the art of seafood preparation at

Bertha Fontaine's Finishing School

BY MARY RYDER

Like most other women, Bertha Fontaine spends a lot of time in the kitchen. But the kitchen where she works, as a seafood home economist for the National Marine Fisheries Service, may be anywhere in the southeastern United States.

A single week's activity for Mrs. Fontaine could include developing seafood recipes in the test kitchen at the NMFS Exploratory Fishing and Gear and Research Station in Pascagoula, Mississippi, driving 70 miles to conduct an out-of-town fish cookery demonstration, flying several hundred miles in a different direction to give more demonstrations, taping a few television shows, and holding training sessions for state home economists.

The Pascagoula test kitchen, her home base, is part of the Division of Marketing Research and Services for the Southeast Region of NMFS. Mrs. Fontaine's supervisor is the regional division chief, whose office is across the Gulf of Mexico, in St. Petersburg, Florida. Her basic responsibilities include training home economists in the arts and sciences of fish cooking, recipe research and development, and giving educational programs.

In carrying out these responsibilities, she travels 16 states. The job has no set routine and offers new challenges every week.

Variety and challenge were precisely what Mrs. Fontaine had in mind when she applied for the job. Teaching home economics in a Pascagoula high school had begun to pall because "it was the same thing over again every year."

Now, after nearly 15 years with the fisheries agency, she can honestly claim that she has "just loved every minute of it, because every day is different."

Her career in seafood home economics has been marked by professional success as well as by personal satisfaction.

In December 1971, the National Oceanic and Atmospheric Administration, parent organization of NMFS, presented Mrs. Fontaine with the coveted NOAA Public Service Award. This consisted of a plaque and $1,000, for "unusually significant contributions to the quality and effectiveness of NOAA's public service programs, contributions having such merit as to bring extraordinary credit to NOAA and the U.S. Department of Commerce."

Jack T. Brawner, chief of the Regional Marketing Research and Services Division, describes the energetic lady as "a professional through and through," and a large collection of awards and honors recognizing her talent and dedication are evidence that his opinion is shared by her employers in Washington as well as by state officials and representatives of the region's food and fishing industries.

Florida's former Governor Claude T. Kirk presented her with a plaque recognizing her contributions to Florida's seafood marketing program; the Southeastern Fisheries Association, a five-state trade fishery organization, has honored her for her services to the fishing industry; the Alabama Fisheries Association awarded her a plaque and an honorary membership in recognition of her services to the seafood industry of that state. She also serves as a seafood consultant to the Alcorn A & M University, and was special consultant to *Better Homes and Gardens* for a seafood cookbook recently published by that company.

Summing things up, Mr. Brawner says that "Mrs. Fontaine has had a dramatic impact on the entire fishing industry of the Southeast and even other sections of the country. Professional foods people and professional foods educators with whom she works recognize her superior talent and recognize her as a competent and imaginative professional."

One rather unexpected side effect of her

continued

As the holiday season approached, she showed TV viewers how to build a shrimp Christmas tree from styrofoam cones, greens, and lots of shrimp.

excellent professional reputation has been the extension of her expertise from fish to fowl; she has been invited by the Alabama poultry industry to serve as a judge in the annual poultry cook-off.

Mrs. Fontaine has a genuine liking for good food. She enjoys cooking, not only during the working day, but also at home, as a hobby. Her enthusiasm for seafood is based partly on her love of variety.

"There are so many things you can do with it—so many *easy* ways to prepare it —to lend variety to menus—things like using it in salads, or serving it with different kinds of sauces—and the beauty of fish is that it is a tender protein, which means it can be cooked quickly. And that is very important, especially for women who work and have to come home and cook for their families."

Mrs. Fontaine has good reason to appreciate the value of seafood in the life of a career woman-mother-homemaker, since she falls into that category herself. She cheerfully admits that it takes more than apparently unlimited energy and love of variety to combine a hectic career as a traveling home economist with a career as a homemaker for a husband and three children.

"I can do it only because I've got a real good thing going for me," she says in her soft, southern accent.

The "real good thing" is an understanding and cooperative husband who works as manager of a motel and restaurant in Pascagoula. The family formerly lived in an apartment in the motel, and has just recently moved into a newly built home nearby. The arrangement has much the same advantages as a built-in-baby-sitter for the three children, Douglass, 11; Rebecca, 7; and Patrick, 4.

Mrs. Fontaine's husband Douglass is close at hand even when he is at work, so that the possibility of illness or other childhood crises is not a source of constant anxiety during her absences.

"It also means I can go off to Atlanta or Mobile without having to worry about whether there is enough milk or hamburger in the refrigerator, because if there isn't enough food on hand, they can always eat in the motel dining room."

Fortunately, she has help with the housework and the children, so that she can enjoy the companionship of her family during her hours at home.

Although a native of Memphis, Tennessee, Mrs. Fontaine has spent most of her life in Mississippi, and has lived in Pascagoula about 20 years. She is a graduate of Mississippi State College for Women at Columbus, and has done some graduate work at the University of Alabama.

During the past six years, Mrs. Fontaine has trained some 25 home economists, involved in state or federal programs, in the use and preparation of seafood.

Her "students" usually come to the Pascagoula laboratory for six weeks. Each is provided with a selection of about 20 recipes, and is taught "everything possible about each recipe." This involves learning not only what to use and how to put it together, but as much as possible about the species of fish or shellfish being used. The teaching process is not confined to laboratory and lecture room, but includes getting out and visiting as much of the industry as possible to learn how seafoods are processed.

"Much of our work is with processed seafood," Mrs. Fontaine observed. "People prefer to buy already-processed seafoods—crabmeat that is already picked, or deveined shrimp, for example."

This preference is related to the increasing number of homemaker-career women. A full-time homemaker frequently has more time than money; the full-time career woman often has less time than money, and prefers to pay more for the convenience foods that demand less of her valuable time and energy.

Before the student returns to her home state, she must give two demonstrations—one an extension-type demonstration, and the other a television presentation.

A well-developed sense of humor is a must in a job that demands constant public contact and the ability to adjust immediately to the unforeseen. Mrs. Fontaine's ability to find the unexpected amusing rather than disastrous has been particularly valuable in her work with trainees. Almost anything can happen—including explosions.

The Case of the Exploding Pizza developed when an understandably nervous student embarked on her television-style demonstration, grimly determined to impress her instructor by constructing an absolutely beautiful shrimp pizza, the shrimp pizza being one of Mrs. Fontaine's own test kitchen inventions.

All went well until the student picked up a can of tomato paste, and failed to notice that the can was swollen. Under normal circumstances, even the most amateur of cooks regards a swollen can as a four-alarm signal of spoilage. But these were not normal circumstances.

The unsuspecting student attacked the tomato paste with her trusty can opener—and the can exploded.

"Tomato paste spewed all over. It was dripping from the ceiling. Her new white uniform was just ruined. It was all over her face, and in her hair.

"Right at first, it wasn't very funny." But, Mrs. Fontaine added philosophically, "there was really nothing we could do about it except laugh, and so we did."

As for the demonstration, "I think we got it done the next day. And it was a simply magnificent shrimp pizza."

But it is the unfinished pizza that has been truly memorable; there are still stains on the test kitchen ceiling, a mute reminder of the wisdom of leaving swollen cans unopened.

When an NMFS fishery home economist is requested to give a demonstration, the agency usually provides the fishery products required. The person or group making the request is responsible for all other ingredients—bread crumbs, flour, condiments,

and the like. This means that a list of the necessary groceries and equipment must be sent ahead of time, so that all will go smoothly when the demonstration gets under way.

Depending on how far out of town the demonstration is held, Mrs. Fontaine may either take the fishery products with her, or may contact a local broker or marketing specialist for assistance.

"We always use things that are available in the area," she emphasizes.

Both availability and regional attitudes toward food are important factors in recipe and product development as well as in giving demonstrations, she says.

A classic in the "availability" category is the NMFS booklet on catfish cookery which includes a recipe calling for macadamia nuts. A product of Hawaii, these nuts are readily available only in areas where grocery stores maintain a well-stocked gourmet section.

It is a source of regret to Mrs. Fontaine that she has been unable to try the macadamia nut recipe.

Gumbo provides a good example of the effect of regional attitudes. In the North, gumbo frequently emerges from the kitchen as a weak-kneed soup with lots of seasoning, little substance, and only an occasional seed or sliver of okra to betray the cook's intention.

Along the gulf coast, gumbo is subtle and substantial, a meal in itself, and the subject of violent and vociferous argument between cooks who hold opposing views.

"Gumbo isn't gumbo unless it contains either file or okra—that's what makes it gummy," Mrs. Fontaine explains, adding confidentially, "personally, I like it with both."

Unfortunately for gumbo fanciers, northern cooks tend to regard okra as no better than a weed, while file—actually a blend of mild spices—is as rare in northern groceries as macadamia nuts in Pascagoula.

One of Mrs. Fontaine's more unnerving experiences with a demonstration involved neither regional prejudices nor unavailable ingredients, but the mysterious disappearance of a carload of groceries.

She was taking "one of the Florida girls and two other home economists" to Hattiesburg for a fish cookery demonstration at the University of Southern Mississippi. It was a prodigious undertaking, involving two cars "and lots of equipment."

The fish to be used in the demonstration was carefully loaded into the car belonging to the girl from Florida, while the equipment was to travel in Mrs. Fontaine's car. Suddenly the driver of the first car announced that she had to go see about a tire, and left the test kitchen.

"We waited and we waited," Mrs. Fontaine recalls, "but she didn't come, and she didn't come. We knew we couldn't wait *too* long, because we had to allow time to drive about 200 miles and prepare the fish, and we were beginning to get a little nervous, because she had the fish.

"Well, finally we just couldn't wait any longer, and we decided we could always stop at the supermarket and pick up some more fish."

So the other home economists crowded into Mrs. Fontaine's equipment-laden car and started out for Hattiesburg. "And 20 miles out of Pascagoula, there was Teena, sitting in a service station waiting for us.

"We never did know just how she expected us to know we were supposed to meet her there."

The group arrived at their destination without further difficulties, and the demonstration went off beautifully, proving once again, in Mrs. Fontaine's opinion, "that even when things start out badly, everything turns out all right."

This attitude, in addition to her competence in the kitchen, is probably a major reason why home economists come from all over the region—and from other sections of the country—to study seafood preparation at the Pascagoula laboratory.

With becoming modesty, Mrs. Fontaine was pleased when a home economist from Maryland came for training at Pascagoula, because macadamia nuts are readily available in the student's home area. "So she can go back and try that catfish recipe."

Boss Brawner had a slightly different reaction, and remarked with understandable pride that the student's willingness to go all the way to Pascagoula for the training available there was "just one more deserved tribute to 'the Fontaine Finishing School.' " □

(Above) In 1971, NOAA honored Mrs. Fontaine with its Public Service Award—$1000 and a plaque. From left, Mrs. Fontaine, Howard W. Pollock, Deputy Administrator, and Dr. Robert M. White, Administrator. (Left) Time out to relax with children Douglass II, Patrick, and Rebecca.

THE NATIONAL WEATHER SERVICE is often thought of as providing the weather, not just predicting it. That's why weathermen often take credit for good weather—they so frequently are blamed for the bad.

The farmer reacts even more than most people, because he has more at stake. If unfavorable conditions are forecast, he takes protective, preventive, or corrective action for his plants or animals. With a favorable forecast his reaction is more positive. He may begin planting, cultivating, spraying, harvesting, cutting hay, or any of a multitude of other chores.

If he didn't know what kind of weather to expect, the farmer would be at a loss. He might lose a crop to a freeze, or plant his cotton too early and discover that soil temperatures had subsequently turned cold, forcing him to replant because of poor germination. Diseases or insects could destroy his crop after rain washed off the pesticides. Millions of dollars would be wasted through poor timing.

Because the elements are so important to farmers, most of them are ardent weather watchers. Many can, to a certain extent, foretell the weather by observing the winds and the clouds. Much of the folklore written on weather has been recorded because of farmers' observations. Their longtime concern for weather has brought about the various versions of the "Farmer's Almanac" that are available, one claiming annual issuance for 180 years, another 155 years.

Ceel Van Den Brink is the National Weather Service's Agricultural Advisory Meteorologist in Lansing, Michigan

Although weather folklore and the almanacs have endured into the modern age, there has been a continuous search for more reliable ways of predicting the weather for farmers. Basic weather forecasts issued by the National Weather Service for the general public no longer meet the specialized needs of agriculture, which has become an increasingly complex and competitive enterprise. Farmers are constantly seeking more detailed predictions of temperature, wind, precipitation, sunshine, humidity, dew, soil moisture, air, soil and leaf temperatures, and other parameters. Furthermore, they ask for this in clear, easy-to-understand language in readily available form. They want better communications with the weatherman.

Because of the extreme sensitivity of most fruits to freezing temperatures, Fruit-Frost Forecasting programs were among the earlier services provided to agriculture, and have been in existence for more than 50 years. Most of these programs are in the citrus areas of Florida and California.

Demands for improved weather services for other kinds of agricultural commodities have led the National Weather Service to establish Agricultural Weather Service programs in several additional areas of the nation, focusing on the requirements of the particular crops or commodities in those areas. *continued*

The farmer is more dependent than most people on weather information, because he has more at stake. A survey in Indiana showed that 68 percent of the state's farmers have radios on their tractors for receiving the latest weather advisories.

A HARVEST OF SAVINGS

The agricultural weather service, soon to be expanded, saves growers more than 60 million dollars each year.

BY CEEL VAN DEN BRINK

AGRICULTURAL WEATHER SERVICE—NOW, AND COMING NEXT

Existing Agricultural Weather Service Program

Program Planned Next

★ Weather Service Forecast Office or Weather Service Office

● Agricultural Service Office

The first such program was established in 1958 in the Mississippi Delta region, where the big crop was cotton. With a return of $40 for every dollar spent, the savings during the first year of operation amounted to millions of dollars. Many other states, with a variety of commodities, soon requested a similar specialized service. In 1962, programs were started in eight other regions. Today, there are 12 areas in the nation having specialized services for agriculture. There are plans for extending services to seven additional states soon.

A recent survey of the value of agricultural weather-service programs in the United States showed that savings ranged from the $152 that one farmer saved in spraying 50 acres of soybeans, to as much as $100,000 that a corporate farm saved in scheduling men and equipment for mechanical-harvest operations in one season. Data from this survey showed that, for an annual expenditure of 1.7 million dollars for agricultural weather services, there was an estimated savings of more than 62.1 million dollars, or a return of $37 for every dollar invested.

All the agricultural weather-service programs are similar in some respects, yet different in others because of varying climatic conditions and differing crop requirements. They are similar in that each area has, or will have: a Weather Service Office for Agriculture, usually located at a Land Grant University or Agricultural Experiment Station, and staffed with an Advisory Agricultural Meteorologist; an observational network for obtaining basic weather information from the agricultural-producing area; a designated Weather Service Forecast Office having responsibility for the specialized forecasts and advisories; and a teletypewriter communications system for transmission of the information to mass news media for dissemination to farmers.

The Advisory Agricultural Meteorologist (AAM) wears many hats. First of all he must be a meteorologist; secondly, an agriculturist. He also must be a supervisor, coordinator, research scientist, consultant, public speaker, and sometimes a writer.

One important duty of the AAM is to seek the cooperation of many individuals and organizations such as Cooperative Extension agents, mass news disseminators, grower organizations, and so on. The AAM is the link between them and the National Weather Service Offices that are contributing to the agricultural weather service programs.

The AAM is directly involved in daily weather reporting. He prepares a daily agricultural weather summary (five days a week), often collaborating with agricultural specialists. These weather summaries are transmitted by teletypewriter to mass news media for broadcast over radio or TV. The summaries may repeat portions of the forecasts, but are primarily interpretations of how past and forecast weather may affect current agricultural operations. The AAM does not try to tell the farmer what he should or should not do, but alerts him to weather developments which may affect his commodities. For example, to help peach growers avoid losses because of over-ripening of fruit, the AAM would advise them whenever extended periods of excessively warm temperatures are expected. Since these conditions hasten maturation, alerted growers would respond by adjusting harvesting schedules.

Infestations of diseases and insects often are determined or heightened by precipitation, temperature, humidity, dew, wind, and sunshine. Weather also plays an important role in killing pests. And of course adverse weather, such as spring frosts, extreme winter cold, drought, heat, and other atmospheric stresses, cause considerable damage or loss to agriculture.

In order to help farmers protect crops and livestock against adverse weather, it is important to sort out the kinds and degrees of effects that weather has on agricultural production. The AAM, usually in close cooperation with agricultural scientists at universities or experiment stations, makes scientific investigations to help promote a better understanding of just how much and in what ways weather affects various plants and animals. Such investigations lead to continued improvements in the day-to-day weather services provided to farmers.

A weather forecast and advisory service for agriculture requires weather observations from numerous points throughout the area being served. Many individuals are needed as cooperative weather observers to take daily observations of basic factors such as temperature and precipitation. Sometimes, observations also include sunshine, dew, soil temperature, evaporation, wind, and other pertinent information. The reports are collected daily at a designated National Weather Service office and transmitted by teletypewriter to other Weather Service offices and to the news media. Forecasters use these observations in preparing detailed weather forecasts and advisories required for agriculture. These observations also

continued

(Far left) Advisory Agricultural Meteorologists collaborate with agricultural scientists to issue important weather-related information to the farmer. By means of teletypewriter, this information is disseminated to mass news media and thence to the grower. (Left) Specially trained agricultural meteorologists at Forecast Offices provide weather information pertinent to agricultural commodities in their areas. (Right) Many individuals are needed as cooperative observers to take daily observations of temperature and precipitation.

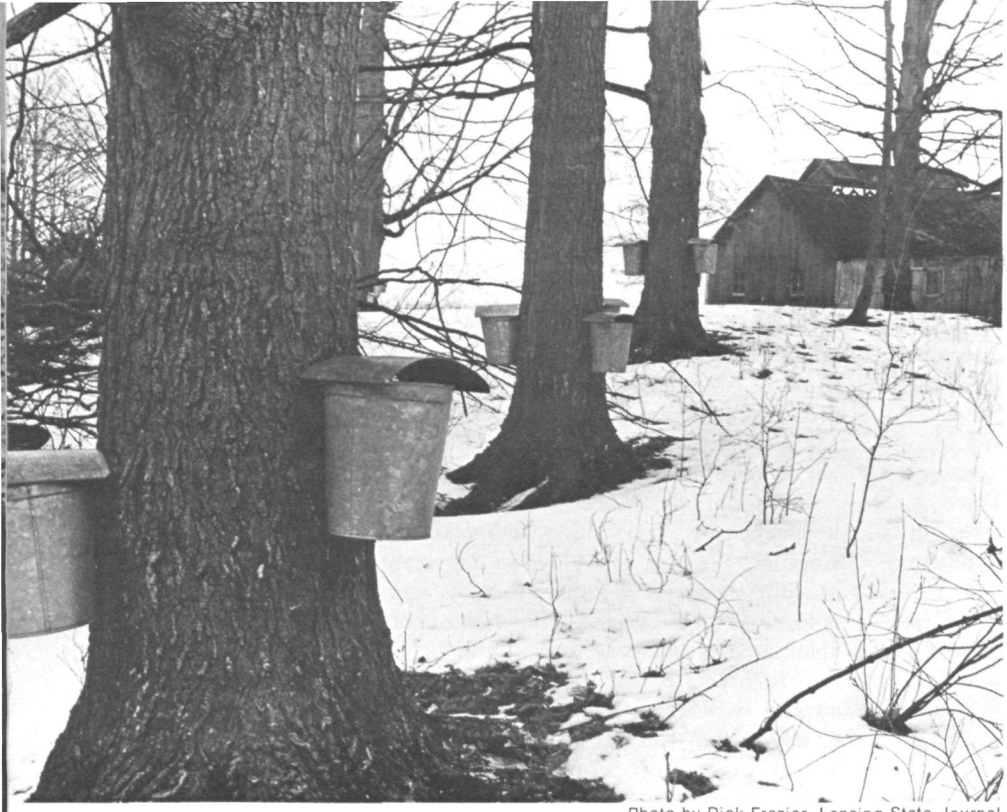
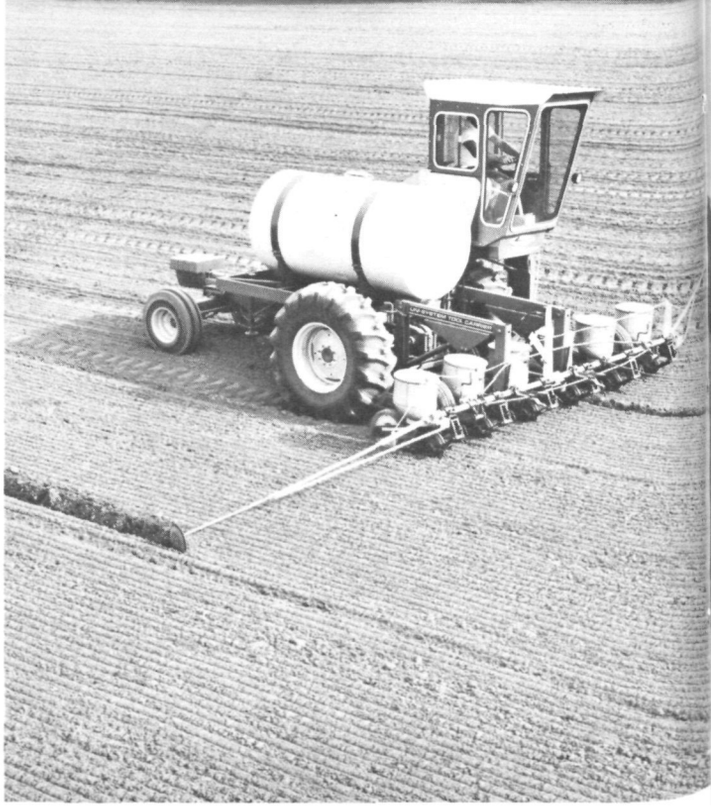
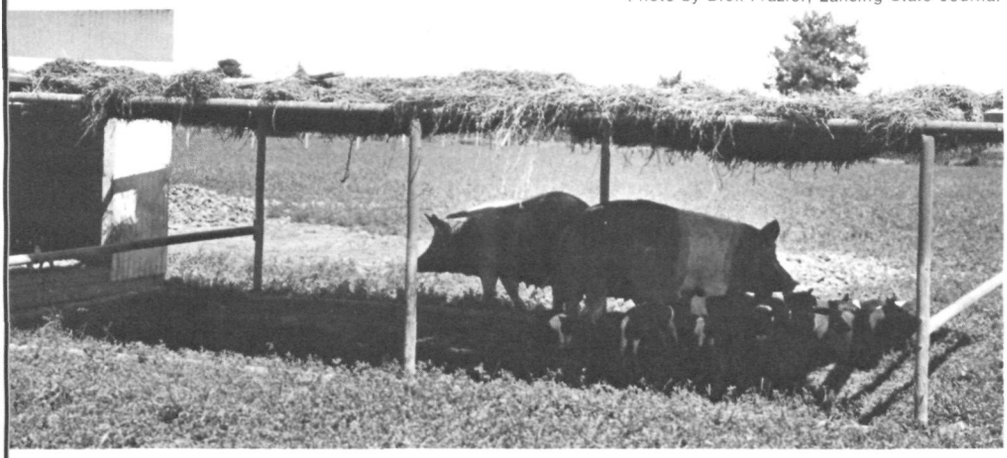
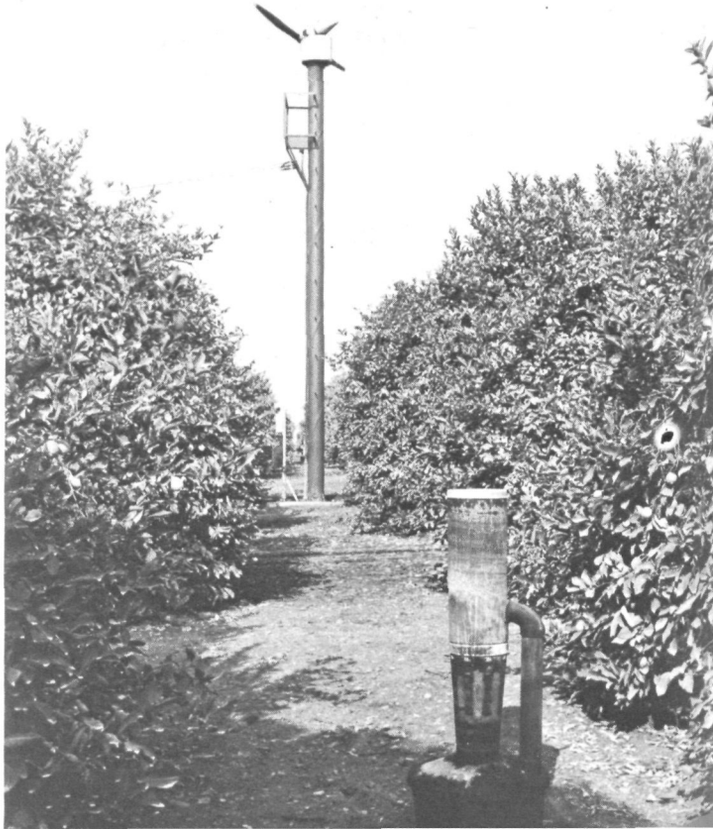


Photo by Dick Frazier, Lansing State Journal





Basic weather forecasts issued by the National Weather Service for the general public no longer meet the specialized needs of agriculture, which has become an increasingly complex and competitive enterprise. Special services for agriculture are now provided in 12 areas of the nation and will be available in seven additional states soon. These services are vital to such agricultural operations as aerial application of pesticides, planting, harvesting of maple sap, protection of livestock from heat stress, supplemental watering and irrigation, and prevention of frost damage to fruit.



contribute to a better understanding of the climatic characteristics of the particular agricultural producing area.

The volunteer observer usually is selected with the assistance of a county cooperative extension agent who is familiar with the area and the people. The observer often is a farmer, or it may be his wife, son, or daughter. Whoever it may be, he or she is a dedicated individual, serving without pay, making a valuable contribution.

Specially trained agricultural meteorologists at Forecast Offices prepare forecasts and advisories providing the weather information pertinent to agricultural commodities in their areas. These forecasts and advisories generally are issued three times daily (early morning, noon, and early evening).

The forecasts include expected cloudiness, range of high and low temperatures, whether or not precipitation is expected, its percentage probability of occurrence, and the expected wind speed and direction.

More detailed information is given in the advisories. The farmer needs to know how much rain is expected, when it will begin and end. He needs to know how soon the dew will dissipate, what the relative humidity will be and what the drying rates may be. Soil temperatures are very important for cotton-seed germination. In cotton areas, detailed soil-temperature forecasts are issued. Forecasts of other weather factors important to particular commodities within areas of concern also are included in advisories.

Sometimes, special operational forecasts are issued. For example, special aviation forecasts are issued for application of pesticides by airplane or helicopter. In livestock areas, advisories alert producers when high temperature and humidity are expected that may result in losses of animals during shipment or confinement.

During early spring, the rate of maple-sap flow is determined by minimum and maximum temperatures, coupled with sunshine. In some maple-sugar regions, advisories are issued alerting producers whenever favorable sap-flow conditions are expected. In areas where tree fruits are an important commodity, growers need to be alerted when freezing temperatures threaten the crop. These are but a few examples of how supplemental advisories from Weather Service offices assist agriculturists.

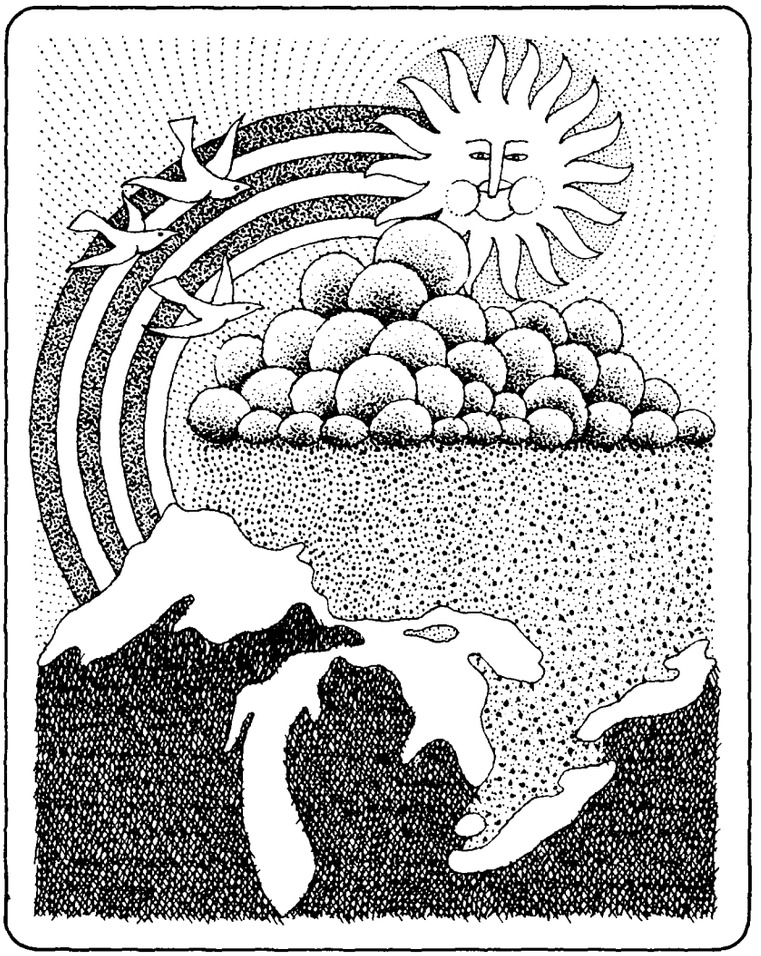
Although there is considerable direct dissemination, the National Weather Service depends primarily on the mass news media (radio, TV, and daily newspapers) to get information to users. Because much more detailed weather information is needed for agriculture, the regular channels of communication are inadequate to handle this flow. Furthermore, weather information for the farmer is often of an urgent nature, requiring rapid dissemination. Thus, the special direct-line teletypewriter networks—which have been established to connect Weather Service offices to radio and TV stations and to daily newspapers—are of particular benefit to agriculture.

The cost of this communications system—the NOAA Weather Wire Service—is borne largely by the National Weather Service. The mass media need only pay for the rental of teletypewriter printers from local telephone companies and for the use of a local line. The weather-wire service provides each subscriber with a printed copy of all forecasts, advisories and bulletins issued by the Weather Service offices in his area. All subscribers receive the messages simultaneously.

Because it is not always convenient or possible for a farmer to be near a radio or television set to get the latest forecast, the current weather information in some areas is entered on a telephone recorder, usually located in a Weather Service office. The farmer simply dials the appropriate number to obtain up-to-date forecasts and advisories geared to current agricultural activities in his area. The only cost to him is the price of a phone call. If he is located within the boundaries of the local exchange, it costs nothing.

Farmers in areas not served by agricultural weather service programs are seeking similar programs to meet their needs. There may be good news for several states which have requested such services. New programs are planned soon for Arizona, Montana, Nebraska, New York, North Carolina, Ohio, and Wyoming.

No matter how effective these specialized programs become, and even if they expand to cover the entire United States, you can be sure that the folklore will remain and the farmer will continue to watch the winds and the clouds for signs of changes in the weather and, on occasion, to consult the "Old Farmer's Almanac" for a supplementary opinion—just to have the benefit of another point of view. □



AN UNKNOWN QUANTITY

BY JAN A. DERECKI

Though it affects water levels and influences the region's climate, evaporation from the Great Lakes cannot be measured directly.

The Great Lakes lose an estimated 43 trillion gallons of water through evaporation each year—a tremendous quantity that represents about ten times the total amount of water used within the highly industrialized basin of the lakes.

Lakes gain water through precipitation on the water surface, through runoff from their drainage basins and, in an interconnected chain such as the Great Lakes, through inflow from the upper lakes. They lose water through outflow and evaporation.

Lake evaporation is the net loss of water from a lake to the atmosphere that results from the continuous processes of vaporization and condensation. In the case of the Great Lakes, the ultimate loss is about three quarters of the water supplied by overwater precipitation, and it has an important effect on the lakes' levels.

Besides purely scientific interest, there are important practical reasons for studying evaporation. Great Lakes levels are constantly changing, as water supply and water loss factors vary. Accurate determination of evaporation rates and development of forecasting methods are needed to improve lake level predictions, which are of vital interest to all lake users. More accurate lake level forecasts for longer periods in the future would provide direct benefits to commercial shipping, hydroelectric power interests, and shore property owners.

There is no direct method of measuring evaporation from large water bodies. Several methods have been developed to determine lake evaporation indirectly, but all of them involve some uncertainties or lack of proper data, so that available values cannot be considered to be more than firm estimates. Three indirect methods are currently in use in the Great Lakes. The first involves balancing water supply and water loss factors, and solving for the unknown evaporation component. The second involves a similar procedure with heat inputs and outputs, since evaporation is basically a cooling process and represents heat loss from the lake. The third method consists of computing the water vapor removed from the lake surface in the exchange of air masses. These methods are called water budget, energy budget, and mass transfer, respectively.

As a cooling process, evaporation decreases with latitude, because colder regions of higher latitudes provide smaller evaporation opportunity. The Great Lakes are oriented in a northwest-southeast direction, from Lake Superior in the northwest to Lake Erie in the southeast. Evaporation from the lakes increases in the same order, being lowest for Lake Superior and highest for Lake Erie. The centrally located (on a north-south axis) lakes—Michigan, Huron, and Ontario—have intermediate evaporation rates. With a total water surface area of 95,000 square miles, spread throughout an area which extends some 500 miles from

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north to south and 800 miles from east to west, evaporation from the lakes varies considerably.

Another important factor affecting evaporation from large water bodies is their heat storage capacity. The heat storage capacity of the lakes varies with lake volume but, since lake areas are relatively constant, heat storage is reflected by lake depths. The influence of this factor is mainly seasonal. Deeper lakes warm up and cool more slowly, producing a delaying shift in the seasonal low and high evaporation losses. Depth in the Great Lakes varies with latitude. The most northerly located lake, Superior, is also deepest with a maximum depth of 1,333 feet. The southernmost lake, Erie, is the shallowest, with a 210-foot maximum depth. Lakes Michigan, Huron, and Ontario again have intermediate measurements—923, 750, and 802 feet respectively.

Average evaporation from the Great Lakes amounts to approximately two and a quarter feet of water per year. This annual evaporation superimposed on water surface area is equivalent to 180,000 cubic feet per second, or approximately equal to the average flow of the St. Clair River, which represents the total outflow of the three upper lakes—Superior, Michigan, and Huron. For individual lakes, the average annual evaporation varies from approximately two feet for Lake Superior to three feet for Lake Erie. Evaporation from the intermediate lakes amounts to about two and a quarter feet for Lakes Michigan and Huron, and two and a half feet for Lake Ontario. During individual years, the amount of water loss through evaporation may vary considerably, with the extreme range of fluctuation approaching two-thirds of the average annual values. The highest variation occurs on Lake Erie, where the annual values may be as much as a foot below or a foot above the annual average.

Seasonal distribution of the normal annual evaporation from the Great Lakes ranges from a low of almost zero to a high seasonal value which varies from about a quarter of a foot for Lake Superior to half a foot for Lake Erie. As with annual evaporation, these normal seasonal values may differ considerably from year to year. The low evaporation season occurs normally in the spring, when evaporation rates vary from slight evaporation to condensation. As air temperatures gradually rise and the lakes absorb heat from the atmosphere, the water warms and evaporation begins to increase. The high evaporation season for most lakes is generally in the fall. Because of great differences in the heat storage capacities, indicated by lake depths, there is considerable delay in the occurrence of the seasonal low and high evaporation rates from these lakes. The low and high evaporation rates from Lakes Michigan, Huron, and Ontario occur about a month later than for Lake Erie, while for Lake Superior the lag is two to three months.

During winter months, ice cover affects lake evaporation by reducing open-water area. Ice cover is normally light on Lake

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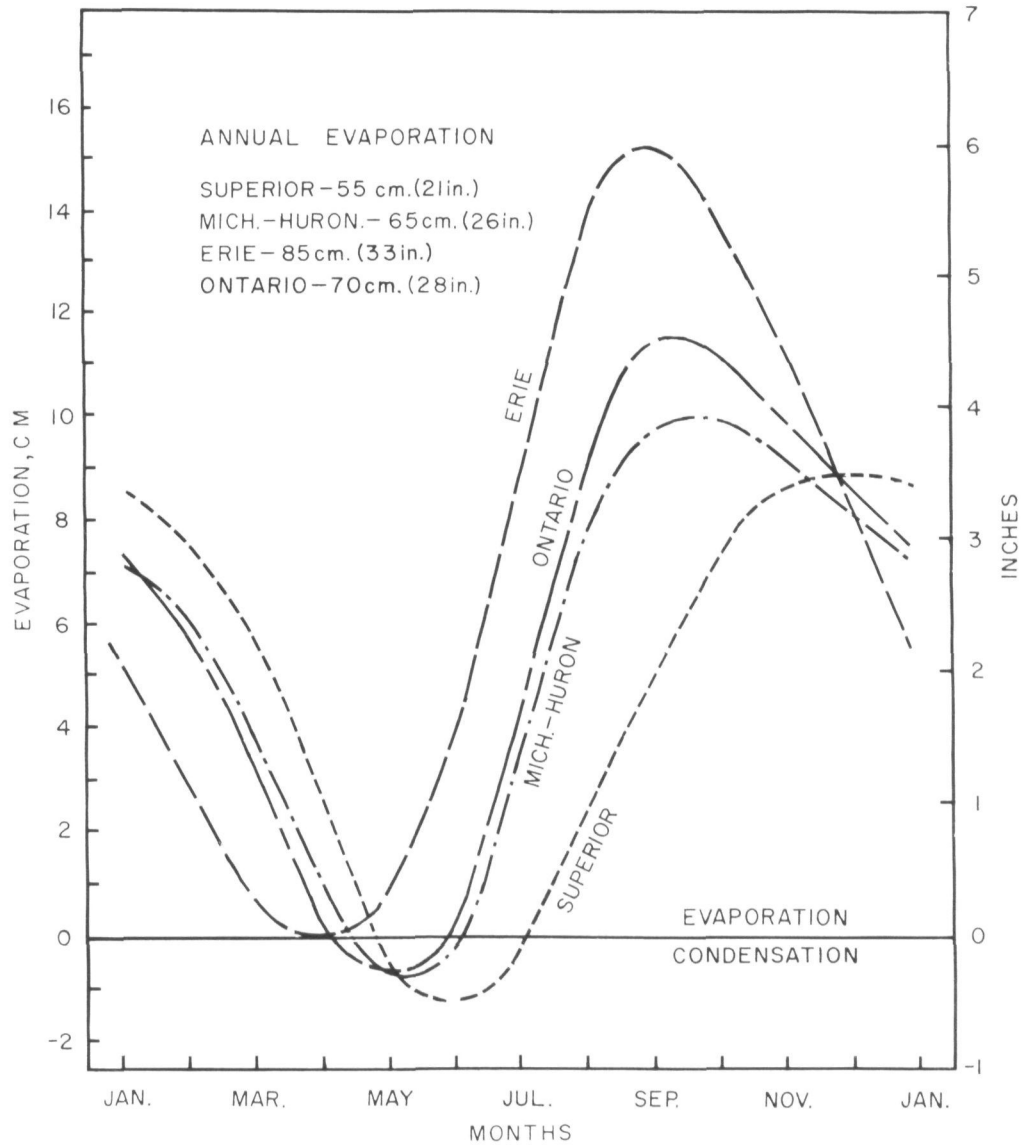
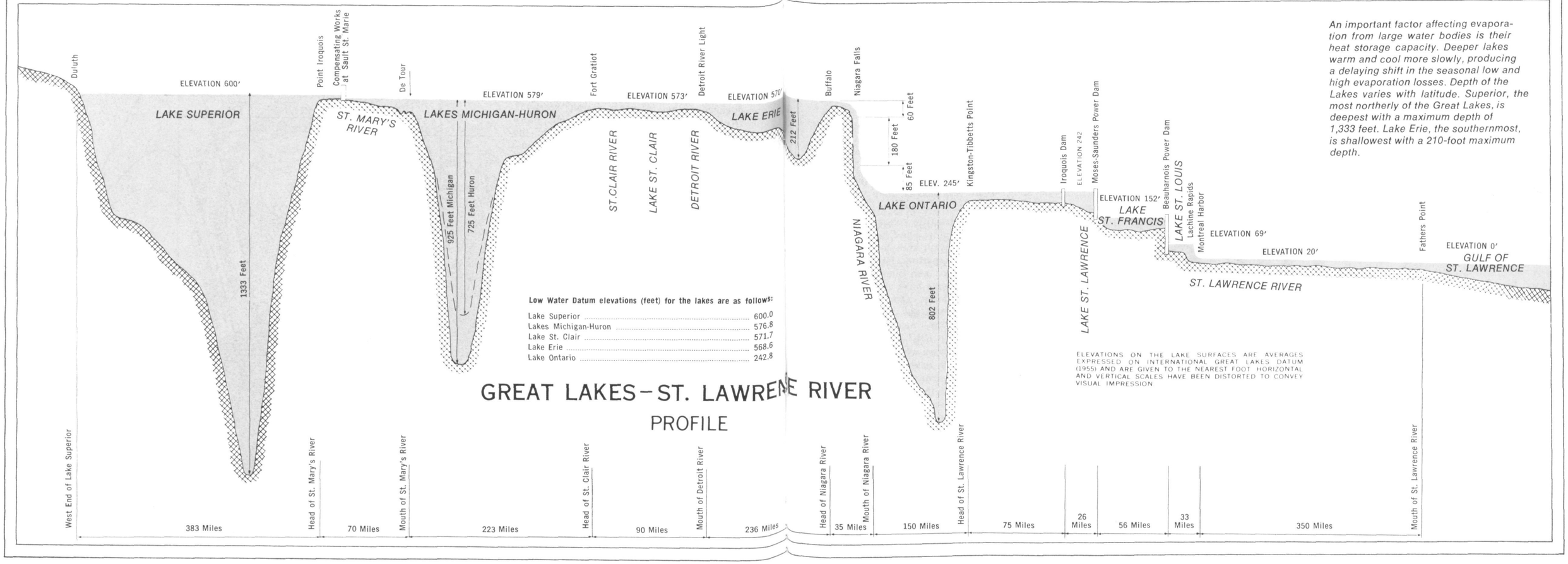
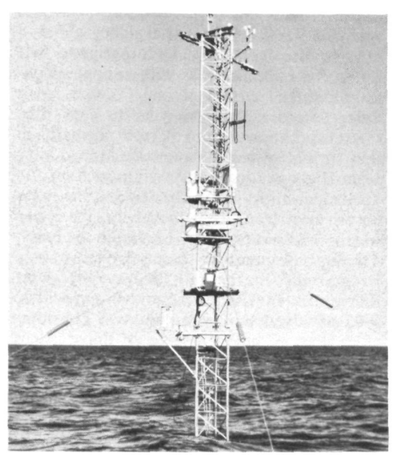


(Top) Evaporation from the Great Lakes varies with the season. Normally, the lowest evaporation rate occurs in the spring and the highest in the fall. (Above) The Lakes lose water through outflow as well as evaporation. About 500 tons of water from other lakes flow over Niagara Falls each minute into Lake Ontario.



GREAT LAKES–ST. LAWRENCE RIVER
PROFILE

An important factor affecting evaporation from large water bodies is their heat storage capacity. Deeper lakes warm and cool more slowly, producing a delaying shift in the seasonal low and high evaporation losses. Depth of the Lakes varies with latitude. Superior, the most northerly of the Great Lakes, is deepest with a maximum depth of 1,333 feet. Lake Erie, the southernmost, is shallowest with a 210-foot maximum depth.



Intensified research programs make use of data from research vessels (left) and from lake towers that measure the interaction between air and water.

Ontario, moderate on Lakes Michigan and Huron, and extensive on Lakes Superior and Erie. Erie has extensive ice cover despite its southern location, because its relative shallowness limits the lake's heat content. The water budget method of determining evaporation is a residual of measured water supply and losses, and is unaffected by the ice cover on the lakes. However, congestion of ice floes in the rivers may cause ice jams, partially blocking the river flow and thus affecting the accuracy of inflow, outflow, and runoff measurements. Other methods of determining lake evaporation are based on exchange of heat or water vapor between water and air. They do not consider modifications introduced to these processes by freezing or thawing of lake waters, and thus do not take into account possible effects of ice cover.

The Great Lakes represent the largest concentration of fresh water in the world, with a total volume of nearly 5,500 cubic miles. Because of their large size, the lakes influence the climate over the lakes and to some extent over adjacent land areas. This lake effect moderates air temperatures, increases winds and humidities, and modifies precipitation patterns. All of these climatic elements are used to compute lake evaporation and should reflect actual overwater climate to produce true evaporation values. Traditionally, climatological data used for the Great Lakes were measured at land stations located around the lakes, because of access and installation difficulties on large water bodies. The required adjustment from shore data to overwater conditions have been developed in recent years and permit reasonable estimates of lake evaporation.

Intensified research programs are being conducted to solve the complex problems pertaining to the climate and other physical aspects of the Great Lakes. These activities were expanded in the last decade by the Lake Survey Center and other agencies with primary responsibilities on the Great Lakes. Existing research includes special precipitation networks, established and operated on lake islands and adjacent shorelines; synoptic surveys conducted by research vessels, that take observations for a whole range of climatic and limnologic parameters; lake towers that give measurements for air-water interaction studies; aerial surveys by aircraft for ice reconnaissance and water surface temperatures; and weather satellites that provide potentially useful information for the investigation of cloud and ice cover on the lakes.

The development of new instrumentation and measurement techniques adaptable to radio-telemetry transmittal and computerized reduction of data represents a tremendous advancement in data collection and dissemination. This is especially true for inaccessible or remote locations, such as the water expanses of the Great Lakes. Remote-control instrumentation makes it possible to conduct research projects on a much more comprehensive scale than was feasible by conventional methods.

A more definite determination of Great Lakes evaporation is one of the many problems that remain to be solved through intensive field projects, such as the current International Field Year for the Great Lakes. □

Modern electronic sounding equipment reveals the peaks, trenches, and plains that lie hidden on the ocean floor.

LAND BENEATH THE SEA

MAN IS TODAY exploring a vast portion of the globe which few have ever seen, a land of giant mountain ranges, stupendous canyons, chasms and valleys, tremendous plains, and mud rivers. It is an inhospitable land where few explorers may ever set foot, for it lies at the bottom of the sea.

This tremendous unexplored area of the earth, a mysterious place covered by some 316 million cubic miles of water, was until recently as little known to man as the planet Mars.

Now man has penetrated many secrets of the depths that surround the giant land platforms on which he lives. He knows that the oceans are not bottomless, as he believed long ago. He has learned that it is not flat, although there are vast portions covered by plains.

The rapid development of ocean sounding equipment during and after World War II has made it possible for him to probe the bottom of the sea without ever setting foot on it or even seeing it. As a result, exciting new discoveries constantly are being made.

In exploration of the deep ocean, research ships of the Commerce Department's National Oceanic and Atmospheric Administration are playing a key role. Modern vessels —equipped with the latest electronic equipment for determining the terrain at the bottom of the sea and the structure underneath—are searching out the secrets which have remained hidden to man since he first appeared on earth.

Foremost among the projects aimed at surveying the sea bottom is SEAMAP (Scientific Exploration and Mapping Program), a major study of the North Pacific ocean bed begun in 1961 by the Coast and Geodetic Survey, predecessor to NOAA's National Ocean Survey. It is part of a worldwide program to map the 71 percent of the earth's surface which is covered by the oceans. So far, only five percent has been reliably charted.

The area being mapped by NOAA's ships covers a 2,000,000-square-mile portion of the North Pacific, extending from Alaska to the Hawaiian Islands and from the Pacific coast westward. The NOAA Ship OCEANOGRAPHER has just completed a four-month survey of the Western Pacific which took it to the Philippines, Hong Kong, and Taiwan. Earlier, surveys by the Coast and Geodetic Survey Ship PIONEER and by the NOAA Ships PATHFINDER, SURVEYOR, and OCEANOGRAPHER have brought to light fascinating information about the bottom of the sea.

In 1955 and 1956, for example, a detailed survey by the PIONEER of an area off the west coast, supplemented by vessels of the Scripps Institution of Oceanography, resulted in the discovery at the ocean bottom of four new fractures, massive gashes in the earth's crust which generally extend east and west for hundreds and often thousands of miles. They were named Pioneer, Murray and Clarion Fracture Zones. These fracture zones are major faults in the earth's crust, the region between two crustal blocks—giant segments of the earth's crust—which are moving with respect to each other.

In 1965, the OCEANOGRAPHER and SURVEYOR investigated an area in the North Pacific which resulted in the discovery of still another fracture, the Emperor Fracture Zone, named after a nearby chain of underwater mountains. The discovery was announced in 1967 after the data gathered by the ships had been prepared for computer processing by scientists at the Pacific Oceanographic Laboratories in Seattle, Wash.

Indicative of the size of fracture zones, the Emperor Fracture Zone was found to be some 4000 feet deeper than the surrounding sea floor and extended 600 miles.

Other east-west fracture zones have been discovered in the Pacific. The Chinook Fracture Zone further north and, to the south, the Mendocino, Clipperton, Easter Island, Challenger, Fernandez, and Eltanin Fracture Zones. Several fractures have also been discovered in the Atlantic Ocean: the Jan Mayen Fracture Zone; and the Oceanographer Fracture Zone, named after the ship which found it in 1967.

Several fracture zones which extend generally north and south have been discovered in the North Pacific, near the Aleutian chain of islands. These are the Amlia and Adak Fracture Zones. These discoveries, too, resulted from the processing of OCEANOGRAPHER and SURVEYOR data by the Pacific Oceanographic Laboratories. Giant deep sea channels also have been found in the Gulf of Alaska area. As sea mapping continues, other fracture zones and sea bottom features surely will be discovered in the Pacific and Atlantic Oceans and elsewhere on the globe.

Among the most fascinating sea floor features are the gigantic mountain ranges. The most spectacular is probably the Mid-Atlantic Ridge which was detected before the era of electronic sounding. It begins generally north of Iceland and continues to the South Atlantic and further around the globe. This mountain range is on the average about 8,000 feet high and covered by approximately 1¼ miles of water. At various points, however, it rises above the sea in the form of such islands as Iceland, a hotspot pile of lava superimposed upon the ridge, and the Azores, seamounts rising astride the ridge. Extending down the center of the range is a valley through which material rises from the earth's interior.

Other mountain ranges are to be found elsewhere around the globe and more will undoubtedly be discovered as the mapping of the oceans proceeds. In 1965, for example, scientists conducting a study of data based on soundings taken from aboard the PIONEER uncovered the existence of a vast undersea valley, 600 miles long, 25 miles wide, and surrounded by towering mountain peaks, beneath the Andaman Sea in the Indian Ocean. It lies buried one to three miles under the sea.

The valley is similar to the rift valley of the Mid-Atlantic Ridge. It was found to extend from the northern tip of Sumatra in the Indonesian Archipelago to Narcondam Island, about 250 miles southwest of Rangoon, Burma. The valley's length is equivalent to the distance between Washington, D.C., and Chicago.

A six-month study of the PIONEER data revealed other fascinating aspects of this world beneath the sea. The valley is apparently an extension of the Irrawaddy River in Burma. It has been filled with mud and sand deposited by the river over hundreds of thousands of years. The length of the valley, both on land and under the sea, is approximately 1700 miles, equivalent to the distance between Washington and Denver, Colo.

The valley is part of the volcanic island arc which includes Krakatoa, famous for its catastrophic explosion in the last century. Like the Mid-Atlantic Ridge, part of the mountain range, paralleling the valley rises above the surface to form Sumatra, Java, Timor, and the Narcondam Islands in the Indian Ocean. Other mountains are covered by water, including one huge peak which towers 12,000 feet above the seabed, its summit under 3000 feet of water.

Both the Mid-Atlantic Ridge and the Andaman Sea Ridge are active earthquake zones. Iceland is part of a ridge of volcanoes that also includes the Azones. It was in this range of mountains that one of nature's most unusual phenomena, the birth of a volcanic island, was witnessed in 1963.

At a spot in the ocean about 425 feet deep, just south of Iceland, fishermen saw on November 14, a volcanic island rise out of the sea belching fire, smoke and lava. The island is now known as Surtsey.

Undersea trenches often are the site of earthquakes, some of which generate tsunamis, destructive seismic sea waves which can devastate adjacent and distant shores. The submerged trenches which encircle the rim of the Pacific Ocean (the circum-Pacific belt) comprise one of the earth's most active earthquake zones and are sometimes referred to as "the ring of fire."

In addition to mountain ranges, the sea floor is dotted with many individual mountains, probably running into the thousands. These mountains of the sea (seamounts) are relatively isolated features and must rise from the deep sea floor at least 3000 feet to qualify as a seamount. Most are apparently extinct volcanoes, and many have been named and appear on nautical charts.

The U.S. Naval Oceanographic Office estimated in 1968 that at least 1400 seamounts had been discovered in the Pacific Ocean, but it is clear from voyages of NOAA ships alone that many more abound in the sea. The SURVEYOR discovered 80 new seamounts in the Pacific in a three-month period in 1969. Some seamounts are tremendous in size. One, discovered in 1965 by the SURVEYOR, had a base which covered 18 miles, with a crater two miles across and 900 feet deep. This seamount rose 9400 feet above the ocean floor.

Vast areas beneath the sea are virtually unexplored. One is the bottom of the South Pacific. In 1967, the OCEANOGRAPHER made many discoveries in this area while cruising from New Zealand to Chile on a round-the-world trip. It was found that the South Pacific had many more undersea mountains, plateaus, and fractures than had previously been reported.

The OCEANOGRAPHER's discoveries included 25 new seamounts, some of them two miles high; a mountain range about 180 miles wide; various unreported "rock areas," some rising to within 1800 feet of the surface; and portions of the South Pacific ocean basin which were generally deeper, by as much as 3000 feet, than had previously been known.

Some seamounts rise to within a comparatively short distance of the surface. One is the Cobb Seamount, whose top has been explored by various expeditions, including those of NOAA. This seamount lies only 110 feet below the surface about 340 miles southwest of Seattle, Wash. Data gathered by the SURVEYOR last November indicated that the seamount may gradually be rising to the surface, a process which may take thousands of years, barring unanticipated volcanic action.

A seamount which rises even closer to the surface was found by the PIONEER in 1964 in the South China Sea, about 90 miles off the Philippines. Oceanographers from the PIONEER dived to the peak, only 40 feet below the surface, to explore it firsthand. Dr. Harris B. Stewart, Jr., then Chief Oceanographer for the Coast and Geodetic Survey and now Director of NOAA's Atlantic Oceanographic and Meteorological Laboratories in Miami, Fla., was the first to walk upon the peak of the 10,000-foot mountain.

"It was covered with lush coral groves and there were thousands of beautiful tropical fish everywhere," he related afterward. Steward brought up with him samples of white coral, sediment, and plant and animal life.

It was during the PIONEER's voyage that the ship discovered massive undersea waves 270 feet high, possibly the largest ever recorded. The cause and effect of these underwater undulations are not yet completely understood. An intensive study of these sub-surface waves has been underway for the past several years by NOAA scientists of the Pacific Oceanographic Laboratories.

While the PIONEER was cruising in the Bay of Bengal, it made another remarkable discovery. It found mammoth channels in the bottom of the bay.

Dr. Robert Dietz reported that at least a score of sea channels was discovered off the eastern coast of India.

"These channels are of enormous dimensions," he said. "The largest surveyed by our scientists, located about two miles below the surface, was about four miles wide and 300 feet deep.

"We estimated that it carried a volume of water 25 times larger than that of the Mississippi River, which is about one mile wide and up to 50 feet deep. We followed it for about 200 miles before we lost it."

Dietz said the channels appeared to be dug out of the sea bottom by huge rivers of mud. "Over the years the many rivers which pour into the Bay of Bengal, including the Ganges, Irrawaddy, and Brahmaputra, deposit their mud on the continental shelves, a connecting link with the ocean bottom which begins at the water's edge. Possibly about once or twice each century, this mud suddenly moves with compelling force from the shelves across the bottom of the sea through these huge channels. At some time in the distant past, the mud avalanches cut these enormous channels out of the sea bottom."

Dietz said it is not known what triggers the sudden avalanches of mud at the sea bottom.

Other phenomena of the sea which NOAA ships are exploring are plains which stretch for thousands of miles below the surface. During the SURVEYOR's expedition last November, which covered an 850-by-360 mile area west of Washington and Oregon, oceanographers located the southern boundary of a submerged plain at least as large and perhaps larger than the central United States.

This vast undersea plain is covered with sediment through which deep sea channels meander, forming a pattern more complex than the Mississippi-Missouri River watershed. One channel was estimated to be six miles wide and 600 feet deep. The plain lies an estimated 60 to 600 miles off the coasts of British Columbia, Washington, Oregon, and California, approximately 2½ miles below the surface. The exact dimensions of this flat area, known as Tufts Plain, are unknown because its western and northern boundaries have not yet been determined.

Still another phenomenon of the sea is the tremendous trenches that dwarf in size the largest to be found on land. Of these depressions in the sea floor, the Aleutian Trench, for example, which generally parallels the southern edge of the Aleutian

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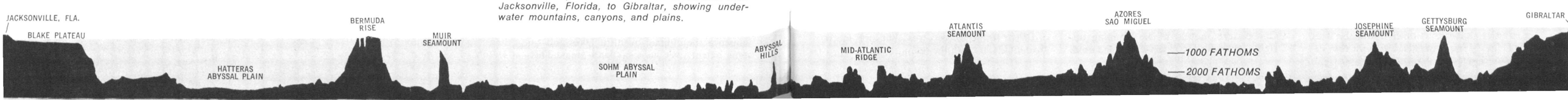
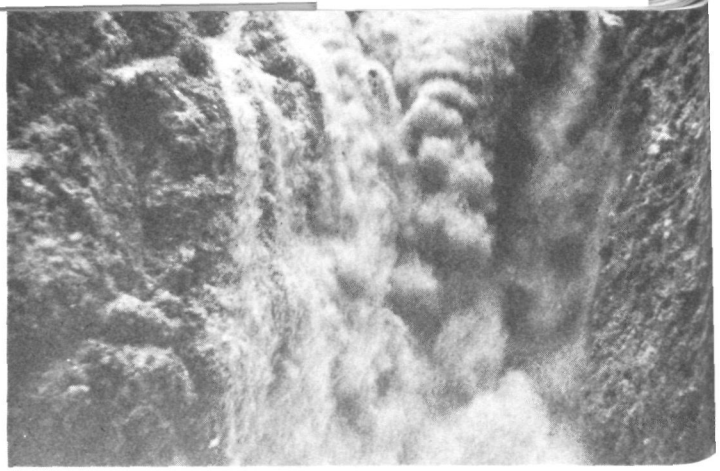
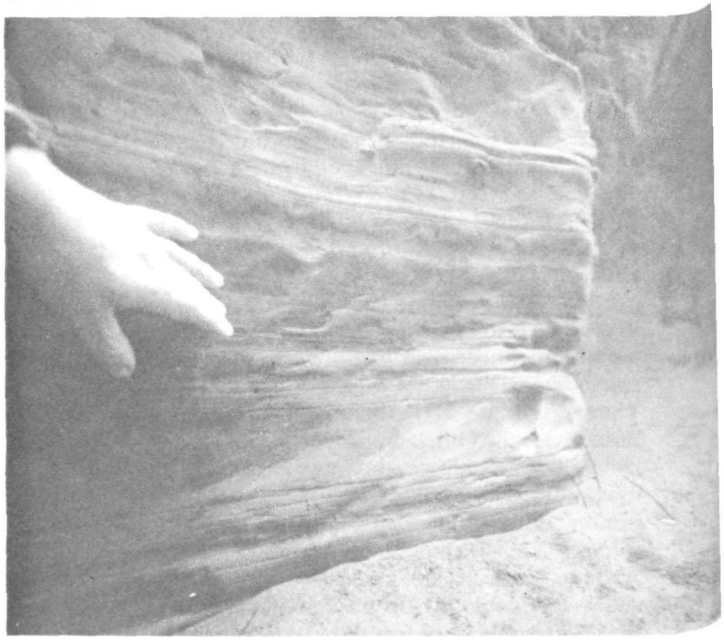
Cross-section profile of the Atlantic Ocean floor from Jacksonville, Florida, to Gibraltar, showing underwater mountains, canyons, and plains.







(Left) Divers explore an undersea canyon off Baja California. (Top right) Submarine landfalls erode a canyon's granite walls. (Right) Gravity pulls sediments down canyon walls, leaving striations in the rock.

Island chain, extends almost four to five miles below the ocean surface for about 4000 miles from the Gulf of Alaska to the Kamchatka Peninsula in Siberia. There it hooks up with the Kuril Trench, which proceeds south off the Asiatic coast and continues into Japan, Izu, and Mariana Trenches, some 8000 miles in all, ending up, as it were, at one of the world's greatest known ocean depths in the Mindanao Trench near the Philippines.

Man has not yet fathomed all the mysteries of the bottom of the sea. Many questions remain unanswered.

Are there monsters dwelling in this strange world of sunken mountains, plateaus, chasms, and deeps? There are scientists who are not prepared to say such creatures do not exist. Oarfish 40 to 50 feet long and giant squids with tentacles 40 feet long have been discovered.

And what of drowned continents? Will fabled Atlantis, the civilization which rose in 10,000 B.C.—so the story goes—and then sank beneath the waves, ever be found?

And buried cities. Are they just fantasy?

In Gardner Soule's *Undersea Frontiers*, published by Rand McNally & Co., these passages appear:

As Bob Menzies of Duke University cruised almost four miles above the floor of the Milne-Edwards Deep of the Pacific's Peru-Chile Trench, he tried, with his deep sea cameras, to solve some of the mysteries of the trench. Some of his photographs, instead, created a new riddle of the seas.

Aboard the *Anton Bruun*, a specially built apparatus lowered cameras, at the ends of steel cable, to as far as 18,000 feet down. One day, about 20 miles from the island of Hormigas de Afuera, Dr. Menzies, who is now at Florida State University, and his scientists lowered their cameras to a point about 6,000 feet beneath the sea, on the side of the Milne-Edwards Deep. Sonar aboard the *Anton Bruun* had indicated some strange shapes on the side of the trench. The shapes did not seem to belong there. So the cameras went down to take photos.

When developed, the pictures "showed what appeared to be columns. Carved rock columns."

The book continues:

With a Lamong 35-millimeter multishot underwater camera, Dr. Menzies took a total of about 1000 photographs. Most clearly showed mud strewn with animal tracks and remains. But some clearly showed what seems to be joined rock.

One picture showed pillars standing upright—extending four feet out of the mud. Other pictures showed rocks that look like pillars that have fallen over.

When Dr. Menzies tried again to locate and again to photograph the upright columns, he failed to find them. This is understandable: A change in bottom currents alone could have swept his camera away from the spot. Instead, he found more fallen pillars. Some of the pillars appeared to have some kind of writing on them.

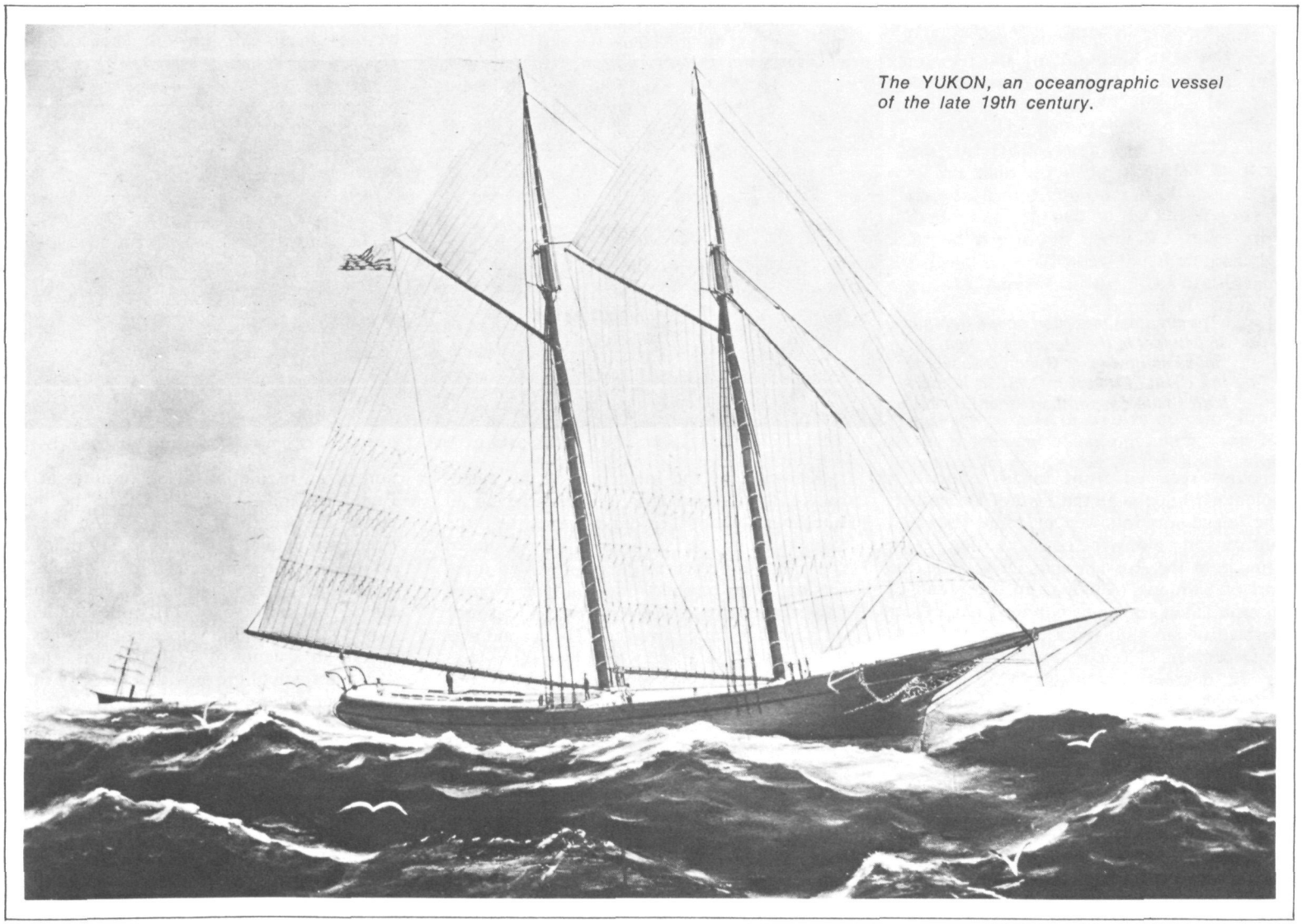
The numbers three and nine seem to show up on some of the lying-down pillars, but these could be tracings made by marine animals. Even so, Dr. Menzies thought these tracings unusual . . .

"We did not find these structures elsewhere," Dr. Menzies said. "Elsewhere the bottom is mud, as would be expected." The ship's sonar showed other irregularities in the topography of the ocean floor in the same area.

It seems incredulous, the idea of a sunken city," Dr. Menzies comments.

To which the author adds, "But not impossible. We already know of other sunken cities."

Other sunken cities, yes, but not more than a mile beneath the sea. □



The YUKON, an oceanographic vessel of the late 19th century.

PIONEERS OF OCEANOGRAPHY

BY ALBERT A. STANLEY

With the crude instruments available to them, ingenious 19th-century scientists obtained amazingly accurate information on ocean depths

LITTLE MORE than a century ago, the earth's ocean basins were popularly believed to be monotonous, level plains sloping gently away from the continents to deep central depressions.

But the sea's depths were unknown and far beyond the reach of the crude measuring devices then available. In 1840, Sir James Ross obtained a sounding of more than 13,000 feet in the South Atlantic Ocean, using a specially constructed line attached to a 76-pound weight. This depth is shown today on modern small-scale charts of the South Atlantic.

It was Professor Alexander Dallas Bache, second Superintendent of the U.S. Coast Survey, who achieved a historic advance using tidal records to calculate the mean depth of the Pacific Ocean.

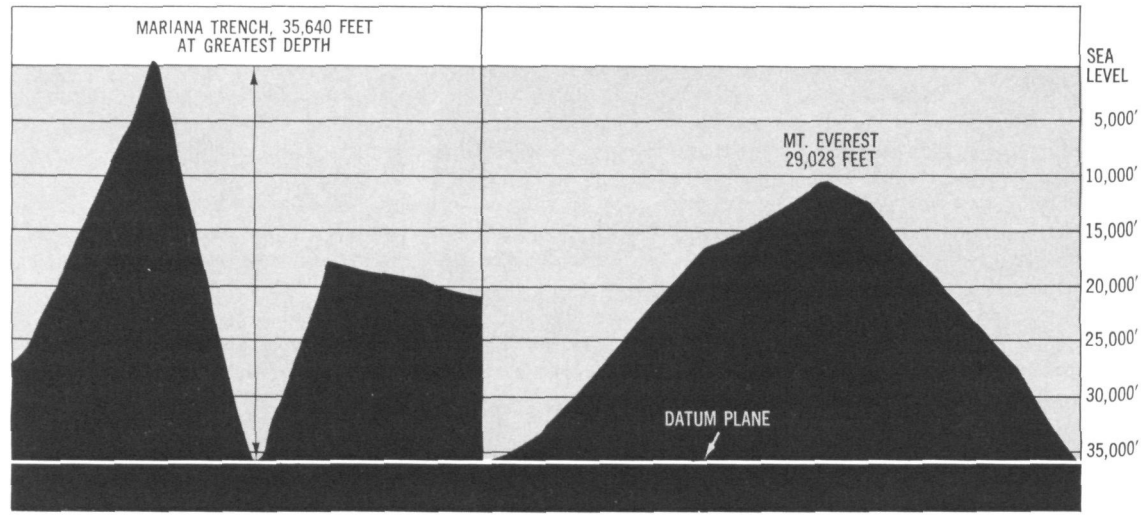
Professor Bache, a leader among the nation's pioneers of oceanography, was the great-grandson of Benjamin Franklin, who had alerted the scientific world to the existence of the Gulf Stream, and Bache himself initiated the first scientific investigations of this great ocean current.

His analysis of Pacific Ocean depth was triggered by a significant event which occurred in the Pacific Ocean in 1854. The engineer in charge of tidal observations on the Pacific coast directed the Superintendent's attention to singular curves that were traced by the self-registering tide gages at San Diego recording the tides from December 23 to 25, 1854. He pointed out that the irregularities of the curves could not have been caused by storm disturbances, since the meteorological records for the whole coast indicated normal weather for that period. Moreover, the length of the wave was too great to have resulted from the recorded tidal action.

The self-registering gage at San Francisco showed similar irregularities for the curves for the same period, but the records from Astoria showed little or no special irregularity. These were the only self-registering gages in operation at that time. Some months later,

continued

Albert A. Stanley retired recently after a long and distinguished career in the National Ocean Survey.



The greatest recorded ocean depth is 35,640 feet in the Marianas trench, 200 miles southwest of Guam. Discovered by the CHALLENGER in 1951, it is more than a mile deeper than Mount Everest is high.

accounts received from Japan reported a violent earthquake on the 23rd of December. The quake was followed by rapid rises and falls of water along the coast, causing severe damage to the Russian ship DIANA in the port of Shimoda (Simoda) in the island of Honshu (then known as Niphon). An officer of the Russian ship reported that at 9 a.m. on December 23 (clear weather, thermometer 72 degrees, barometer 30), a severe earthquake shock was felt on board and shaking the ship in a violent manner. The shock lasted for five minutes and was followed at quick intervals by rapid and severe shocks for 30 minutes. At 9:30 a.m., the sea was observed washing into the bay in one immense wave, 30 feet high, with terrible velocity. In an instant, the town of Shimoda was overwhelmed and swept from its foundations. This advance and recession of the water occurred five times.

Commodore M. C. Perry further contributed to the record of this event in a report which stated that Shimoda had suffered dreadfully since his visit there. On December 23, several severe earthquakes were experienced, and the sea rose in a wave five fathoms above its usual height overflowing the town and carrying houses and temples before it in its retreat. When the water fell, it left but four feet of water in the harbor. It rose and sank this way five or six times, covering the shores of the bay with wrecks of boats, junks, and buildings. Commodore Perry reported that only 16 houses were left standing in the whole area, and the entire coast of Japan suffered from this calamity. Yedo itself was injured, and the city of Osaka was entirely destroyed.

Also, an extraordinary rise and fall of the tide occurred on December 23, 1854, at Peel Island, one of the Bonin Islands. The first rise noted was 15 feet above high water, followed by a fall which left the reefs entirely bare. This irregularity continued throughout the day and on December 25, the water at Peel Island rose to 12 feet above normal.

Bache reasoned correctly that the irregularities observed at San Diego and San Francisco were produced by the same cause which determined the extraordinary rise and fall in the harbor of Shimoda, Japan, and at Peel Island.

Knowing of the incidence of the earthquake, the Coast Survey scientists began an intensive study of the tidal curves at the three stations along the Pacific coast. It was noted that the San Francisco curve presented three sets of waves of short interval. The average height of the first wave was about a half foot on a tide which fell two feet. The second was 0.2 of a foot on a tide which rose three feet, and a third followed less than 0.1 of a foot on a tide which fell some seven feet. The phenomena occurred on a day when the diurnal inequality of the tide was considerable.

The same condition was observed from the record of the San Diego tide station. The observations at San Diego confirmed in general the inferences that Bache derived from San Francisco. The record from Astoria shed no light on the subject; the bar at the entrance of the Columbia River would explain why the oscillations were lost or greatly reduced at Astoria, even if they arrived off the entrance of the river. The distance from San Diego to Shimoda was computed as 4917 nautical miles and from San Francisco to Shimoda as 4527 nautical miles.

From these observations, computations, and the records of the earthquake, Bache determined the mean depth of the Pacific Ocean in the path of the earthquake waves. By establishing the rate of motion as about 6.0 to 6.2 miles per minute and for the duration of an oscillation of 35 minutes at San Francisco and 31 at San Diego, he determined the length of the waves on the San Francisco path at 210 miles to 217 miles and on the San Diego path, 186 to 192 miles. He ascertained from published encyclopedia tables that a wave of 210 miles in length would move with the velocity of six miles per minute in a depth of 2230 fathoms. One of 217 miles would move with a velocity of 6.2 miles per minute and a depth of 2500 fathoms. The corresponding depth on the San Diego path was then determined to be 2100 fathoms. The elapsed time at San Diego between the occurrence of the earthquake and the wave arrival at the tidal register was about 10 hours. The speed and length of the seismic wave enabled Superintendent Bache to arrive at a highly accurate estimate of the mean depth of the Pacific Ocean along the track between Japan and the U.S. Pacific coast.

A.D. Bache

Application of this law by Superintendent Bache gave an average depth between Japan and California of some 2150 fathoms, which is in fair agreement with the present day figure of 2350 fathoms. This estimate of the Pacific Ocean was made when no deep sea soundings were yet available.

Bache's intense interest in the oceans was evident throughout his lifetime. He supported efforts of his time to develop sounding equipment and methods to obtain accurate knowledge of the world's submarine topography.

Mountain chains, enormous depressions, canyons and valleys, isolated peaks and flat-topped tablemounts, and scores of other well-defined features that form a strange world have been charted since his period. Underwater relief cannot be compared to the weathered and sharply eroded continental topography. Now it is known that submarine features have been created by crustal deformations, earthquakes, volcanic action, currents, and waves, and altered by the deposition of sediments and the living creatures of the sea.

The voyages of H.M.S. CHALLENGER (1872-1876) contributed measurably to the science of oceanography. The observations, published in 50 volumes, included the many soundings and bottom observations made

during this world cruise. A bathymetric chart of the oceans showing the deeps resulted from the CHALLENGER expedition, and illustrates 50 or more deeps below 3,000 meters. Many of them are shown as they are known today; others are somewhat erroneous.

In the years that followed, many scientific, naval, and commercial vessels added thousands of new soundings to the hydrographic charts. Their method was that of wire-sounding with the handlead. A weight was attached to a length of wire and lowered into the sea. As the wire was played out, it was carried over a wheel that measured it. However, the wire itself became so heavy as it was lowered overboard, that it was difficult to know when the weight had reached bottom. Soundings of this kind required several hours to complete, during which time the survey vessel had to be stopped. Consequently, wire soundings were taken at widely scattered intervals, and the relief of the ocean floor was not actually revealed. It was evident that canyons, trenches, seamounts, and pinnacles could not be discovered with the wire and lead; however, some very accurate soundings were accomplished by this method and the results are valued by oceanographers. On May 16, 1930, H.M.S. WILLERBORD SNELLIUS made the deepest wire sounding ever obtained in the Philippine Trench at 33,500 feet.

After World War I came the development of the echo-sounder which revolutionized the field of hydrography. While the wire soundings required several hours to perform, the electronic echo-sounder could complete several soundings in less than a minute. With the survey ship moving along a predetermined course, a continuous profile of the ocean floor is traced. From its earliest development the echo-sounder was employed by the Coast and Geodetic Survey on its survey vessels.

Much credit is due the hyrographer and oceanographer whose persistence and diligence in this vast and diversified field have provided a new concept of the ocean bottom topography. From the increased oceanic exploration of today, the secrets of the sea, being rapidly revealed by intensive hydrographic investigations, are reflected in bathymetric and hydrographic charts published by maritime nations.

The Pacific is the world's deepest ocean with an average depth of 14,000 feet. The greatest recorded depth was discovered in 1951 by the CHALLENGER in the Marianas trench about 200 miles southwest of Guam. This depth of 35,640 feet is more than a mile deeper than Mt. Everest is high. Other great Pacific depths are 34,884 feet in the Tonga trench, 34,049 feet in the Kuril trench, and 25,046 off Chile and Peru. Depths occurring in the close proximity to the continental margins of the western Pacific include a maximum of 34,438 feet in the Philippine trench, the Bougainville-New Britain trench with a 29,987-foot depth, and the Nansei Shoto trench reaching a maximum recorded depth of 24,629 feet.

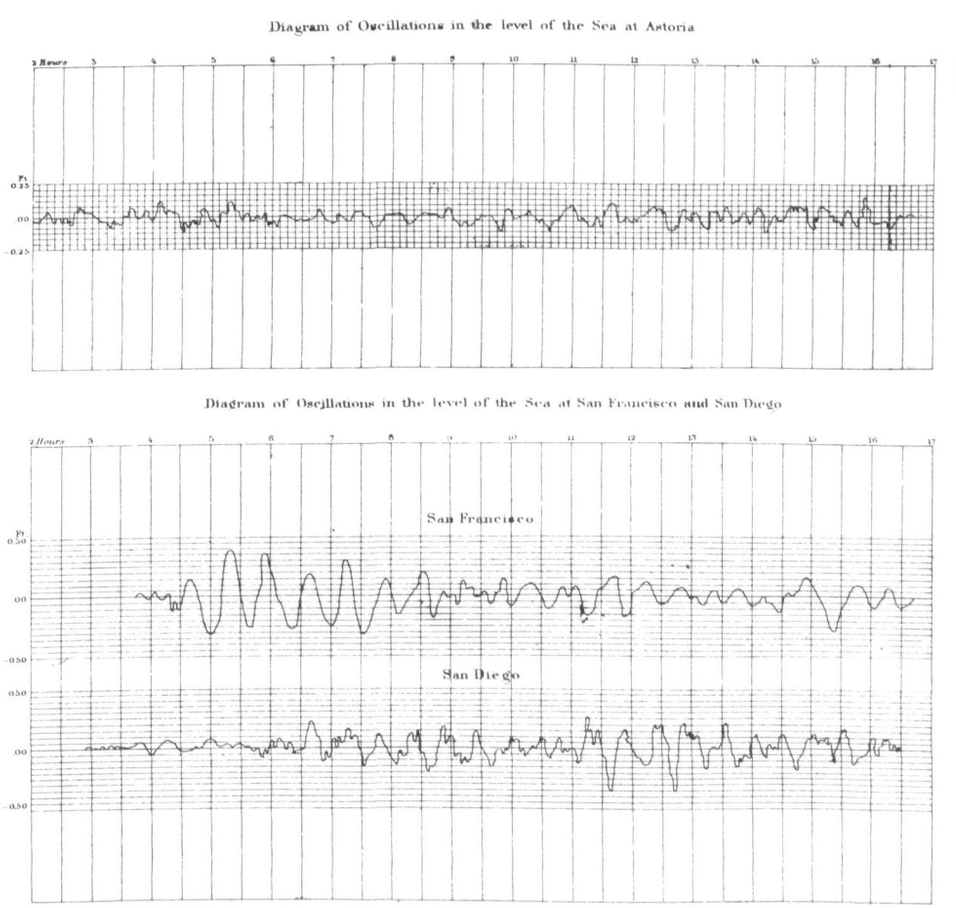
In addition to the great depths of the Pacific Ocean, there are four deep-sea depressions located in the Atlantic. The Puerto Rico trench is the deepest, in which the Milwaukee depth of 30,180 feet has been located. The Cayman, South Sandwich, and Romanche depressions comprise the other three deeps. The Romanche depression is located in the equatorial Atlantic between Brazil and Africa. It is not actually a trench, but a furrow in the ocean floor along the mid-Atlantic ridge.

The Indian Ocean contains one major trench, the Sunda depth at 24,458 feet, located south of the Island of Java. The Weber deep of 24,409 feet is located in the Banda Sea among the Islands of Indonesia, and the Wharton deep of 21,191 feet is a bowl or saucer-like depression located west of Australia. The average depth of the Indian Ocean is 13,000 feet.

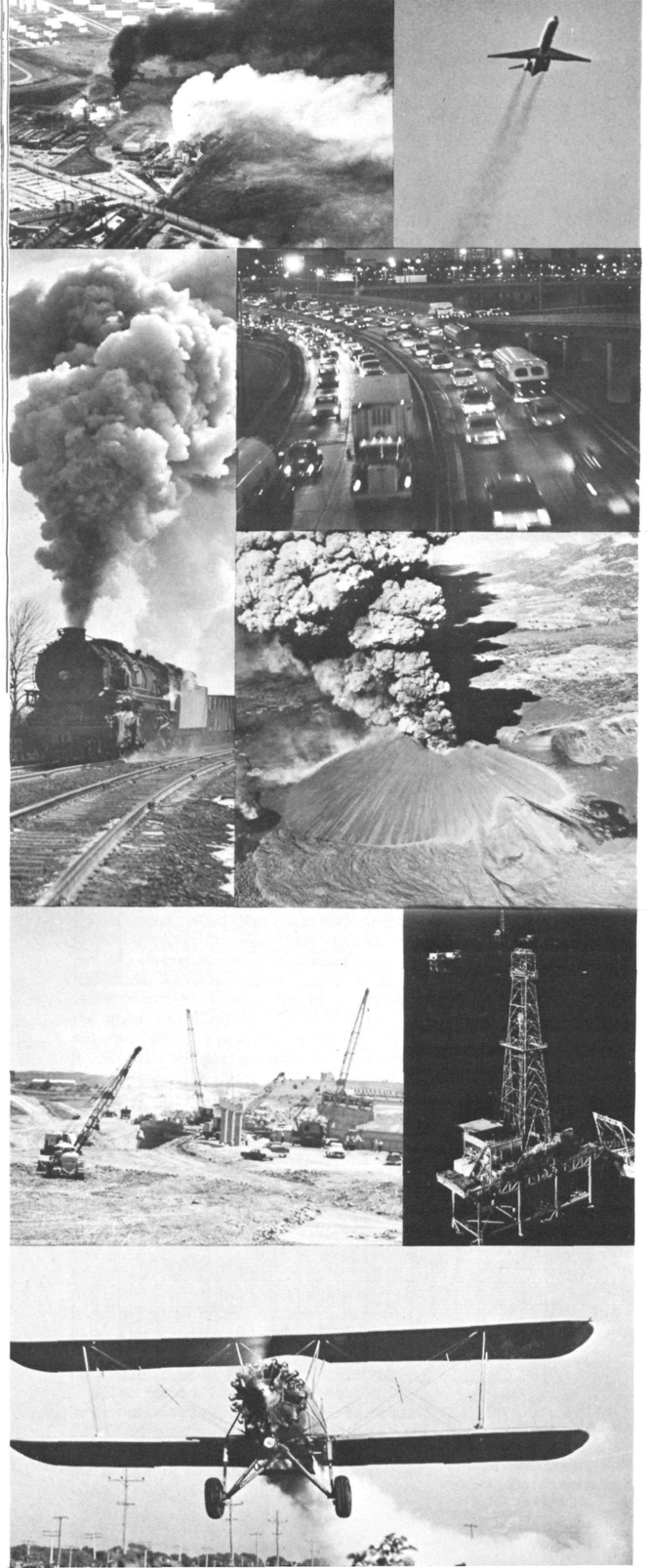
In December 1952 and January 1953, the research vessel HORIZON, operated by the Scripps Institution of Oceanography, made a number of soundings in the Tonga trench, the deepest of which was computed to be 34,884 feet. This would be the greatest depth in the Southern Hemisphere and second only to the world record, CHALLENGER, depth.

In January 1968, the NOAA Ship DISCOVERER, enroute to Tristan da Cunha on a 20,000-mile expedition in the South Atlantic, resurveyed the 47-square-mile area where Sir James Clark Ross made the first successful deep sea sounding in the Atlantic in January 1840. In command of H.M.S. EREBUS, Ross had measured a depth of 2425 fathoms in latitude 27°26′ S, longitude 17°29′ W. The depth obtained at the Ross site by the DISCOVERER was about 325 fathoms less than the depth reported by Ross. However, a maximum depth of about 2400 fathoms was obtained by the DISCOVERER in a broad depression about 3.5 miles from the Ross site. Whereas the discrepancy is about 15 percent at the Ross-documented position, it is only one percent if the maximum depth obtained by the DISCOVERER is considered. Dr. Robert S. Dietz, of the Atlantic Oceanographic and Meteorological Laboratories, has suggested that either Ross's position was in error by five miles or more, or the movement of bottom contact was not immediately recognized in the Ross sounding.

Modern oceanographic investigations reveal new and more profound dimensions of the vast oceanic domain. Bathymetric and geophysical mapping programs greatly extend map coverage of the world beyond the edge of the sea to portray the continental shelves, submarine canyons, and the great ocean trenches, all of which are very much a part of earth geography. □



Professor Bache's analysis of Pacific Ocean depths was triggered by the irregularities in West Coast tidal records that followed a violent earthquake in Japan on December 23, 1854.



YARDSTICK OF ENVIRONMENTAL QUALITY

BY PATRICK HUGHES

The Environmental Data Service's long-term records provide a measure of man's damage to nature.

To what extent is man altering the environment? How will such changes affect human civilization? Can the alteration or changes be prevented or reversed?

For the many scientific investigations now seeking the answers to such questions, information on the past state of the earth, its atmosphere, and oceans is an indispensable starting point.

Historical environmental data are essential to assess the "quality" or present state of the environment, to document its long-term trends, and to conserve its resources for future generations to enjoy. It provides the yardstick needed to measure environmental quality or degradation.

Environmental observations have three useful lives: they are first synthesized to describe the current state of the environment; they may then be extrapolated to provide short-term warnings and forecasts; and finally, they may be used to make environmental decisions at some time in the future. It is the third, historical, life that provides the baseline measure of environmental quality.

To advance man's understanding and use of his physical environment, NOAA gathers data from earth, sea, air, space, and sun; other agencies and individuals gather complementary data to meet their particular objectives. Once the primary collection purposes have been served, the data, through the work of NOAA's Environmental Data Service becomes the documented history of our earth-sun environment—an essential record against which we may measure the effect of man upon his natural surroundings.

Where possible, contamination of air and water must be reversed or at least regulated, but specific decisions must be made rationally—on the basis of documentation of the problem. One of EDS' missions is to document the climatic history of earth and to gage the results of climatic changes over the decades and centuries.

Plants and mills, homes and cars are pouring waste materials into the air—carbon dioxide, smoke, fumes, and even radioactive materials. Dr. J. Murray Mitchell of EDS has been studying the impact of these wastes upon the thermal state of the atmosphere and their relationship to recent climatic changes. His findings to date support the widely accepted theory that the global temperature rise of the early decades of this century was at least partly caused by rising levels of atmospheric carbon dioxide resulting from the widespread combustion of coal and oil. They cast considerable doubt on the role of human activities in reversing this global warming after World War II, when a cooling trend developed that continues today. A number of scientists have ascribed this latter-day cooling to sunlight attenuation effects of a long-term growth in atmospheric dust loading. The results of Mitchell's preliminary analysis suggest, however, that if there has been a significant increase in atmospheric dust loading since World War II, it has been due primarily to an increase in volcanic, rather than human activity.

One direct EDS contribution to climatic change "baseline" measurement is its Reference Climatological Station Program, designed to document long-term global climatic trends. Under this program, a network of "benchmark" stations is being established in the United States and its territorial possessions to monitor climatic change at sites isolated from the contamination of contemporary human activity. To date, about 17 stations have been commissioned, and a continuous search is underway for additional suitable sites. A total of about 50 stations is planned.

Outside the area of climatic change, EDS' mission with respect to environmental quality and conservation consists primarily of providing the baseline information products needed by NOAA and other agencies—both national and international—to document and monitor the character of our physical environment and to plan programs to preserve its quality and conserve its resources.

An example is the International Decade of Ocean Exploration, an intensive program of scientific observations and research designed to provide the intelligence base needed to assess and predict man-induced and natural modifications of the marine environment, to identify harmful or irreversible effects of waste disposal at sea, and to study the impact of man's activities on marine life forms in order to prevent their depletion or extinction.

Much of the data collected during the IDOE will be used to measure man's future impact upon the marine environment. To ensure that this essential intelligence is properly documented and archived, the National Science Foundation, U.S. coordinator for IDOE, has designated the Environmental Data Service as lead agency for data management and as the data repository for all U.S. IDOE programs. Three EDS data centers—the National Oceanographic Data Center, the National Geophysical Data Center, and the National Climatic Center—are involved in the acquisition, formatting, storage, and dissemination of IDOE oceanographic, geophysical, and meteorological data.

In addition to overall data and information management, EDS has undertaken several IDOE projects to develop specific baseline data products. The National Climatic Center in Asheville, N.C., is coordinating an international effort by the Federal Republic of Germany, the Netherlands, the United Kingdom, and the United States to produce annual historical summaries of sea-surface temperatures, air temperatures, and wind speed and direction over the oceans dating back to 1860. The Center is preparing the summary for the Pacific Ocean and will disseminate the summaries for all oceans in a publication series similar to EDS' decennial "World Weather Records" Series.

EDS' National Oceanographic Data Center in Washington, D.C., is preparing two new bibliographies under the Cooperative Investigation of the Caribbean and Adjacent Regions, an IDOE program. The subjects are marine biology and marine geology and geophysics. The Center previously published a CICAR volume on meteorology and oceanography before the CICAR program was incorporated into the IDOE.

Another cooperative program is the pilot project of EDS and the Environmental Protection Agency to facilitate the exchange of oceanic and coastal zone marine pollution data to advance the environmental missions of both agencies.

Also, EDS' National Oceanographic Data Center is working with NOAA's National Marine Fisheries Service, the Environmental Protection Agency, other Federal and state agencies, and the academic community in developing a prototype marine pollution data bank, which will contain information on mercury, methyl mercury, chlorinated hydrocarbons (such as DDT), sulphides, sulphates, and other pollutants.

In addition to providing baseline data and information to others, EDS scientists themselves seek new applications of the historical data base to environmental problems. One of these applications is vital to the management and conservation of oil, gas, and electricity.

Herbert C. S. Thom devised the statistical method now used to derive heating and cooling "degree day" values. Degree days are used to calculate probable fuel consumption for heating and to determine air conditioning requirements and consequent electrical energy consumption. Thom has been working with the Office of Emergency Preparedness to prepare weekly briefings for the President on potential fuel or power shortages in the eastern and north-central United States. He provides degree-day data for key U.S. cities, as well as interpretations of their impact upon fuel oil, gas, and electric power-consumption. The Office of Emergency Preparedness uses his information to evaluate the risk of potential fuel shortages and "brownouts," and to plan measures to cope with such events, should they occur.

In a related program—the "Periodic Summarization of Climate"—the Environmental Data Service's National Climatic Center is preparing new, 30-year climatic baseline averages called "normals" for the United States for the period 1941-1970. The new normals—to be computed for approximately 8,000 geographical points—will in turn provide the basis for new degree-day calculations needed by oil, gas, and electric power producers to estimate need and efficiently regulate distribution and consumption of our dwindling resources of these fossil fuels and fossil-fuel byproducts. Although climatological data and data products—including degree-day values—are routinely published on a monthly and annual basis, longer-term periodic summaries are necessary to provide the historical perspective needed to evaluate climatic change and its implications.

In the United States and several other countries, drought severity is measured by the Palmer Drought Index, developed in the early 1960's by Wayne Palmer of EDS' Laboratory for Environmental Data Research. Various government, academic, and commercial groups use this data-derived tool to evaluate the effects of prolonged periods of drought on the quantity and quality of urban water supplies. The Crop Moisture Index—a derivative of the Drought Index—is used by both state and federal agencies as an early warning system for wind erosion and potential agricultural water supply shortages.

Another aspect of climatic and agricultural interaction that is arousing particular environmental concern today is the widespread use of chemicals in the production of crops and livestock. Pesticides, fertilizer, growth regulators, and hormones are applied freely during many phases of agricultural production, and our abundance of food and fiber is to a large degree a result of their use. Unfortunately, the quality of the environment has suffered as a result.

Sunshine, wind, rain, dew, and ground water all contribute to the dispersion of these chemicals from the areas of application; as a result, they often pollute the biosphere. A prime example is the choking of streams and ponds with algae produced by nitrates and phosphates (from fertilizers) leached through the crop root zone into ground water and streams—a process that eventually results in the death of the fish population by suffocation.

To minimize these and other undesirable environmental effects, it is necessary to adapt crop production to local climatic conditions. The amount of nitrogen escaping absorption by a plant's roots, for example, depends on the temperature, which controls its conversion rate, and the rainfall-evaporation balance, which controls the amount of water available to leach the nitrogen down through the soil. By computing the amount of soil moisture available at the time of application, and planning for expected or "normal" amounts of rainfall and evaporation—as determined from EDS historical baseline weather records—the optimum amount of fertilizer to be used can be determined.

The discharge of chemicals into ground water cannot be completely eliminated by such an approach, but it can be held to a minimum, and a relative assessment made of potential crop yield versus possible pollution risk. Obviously, we need food as well as free-flowing streams.

As in so many conservation areas, the need for production must be measured against the impact on the quality of our environment. Only with an adequate data yardstick can the best choice be made. □

Memories of Mr. Smith

BY RAYMOND WILCOVE

When Robert Rossen's movie "Lilith"—about life and love in a psychiatric institution—was produced in 1963, it featured as the grandmother of actor Warren Beatty "a small, sweet-faced old lady with soft white hair framing a very gentle visage."

This "small, sweet-faced old lady" is in real life the daughter of a distinguished astronomer and physicist who served with the Coast and Geodetic Survey from 1870 until his death in 1912.

She is Lucy Neville Smith, a spry 83, not the least reluctant to reveal her age. For 82 years, she has lived in the rambling white mansion which her father, Edwin Smith, built in 1890 for his wife and family in Rockville, Md. Now, a fourth generation of nephews and nieces share the 16-room, three-story structure on the street her mother Lucy named Forest because it was surrounded by trees.

Still active, despite her years, in community affairs, Miss Lucy has watched the decades come and go in the old house filled with memories and mementoes of a romantic period in the life of the oldline government agency whose activities are now carried on by NOAA's National Ocean Survey.

The home has provided a haven for many of the descendants of Edwin and Lucy Smith, including three great-great-nephews and one great-great-niece who live with her now with their mother while their father is away in the Navy.

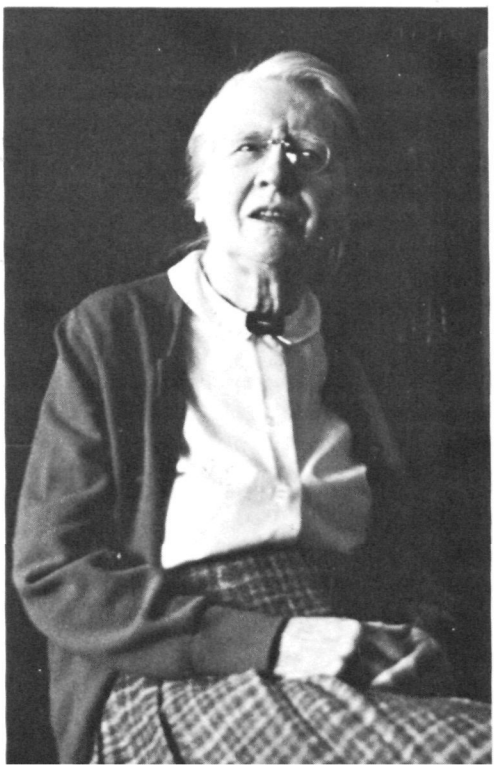
"I've just stayed on," said Miss Lucy. "My father said 'don't get rid of the house at any time because it's always nice to have a place to come back to.'" And Miss Lucy hasn't, turning down substantial offers for the house and land.

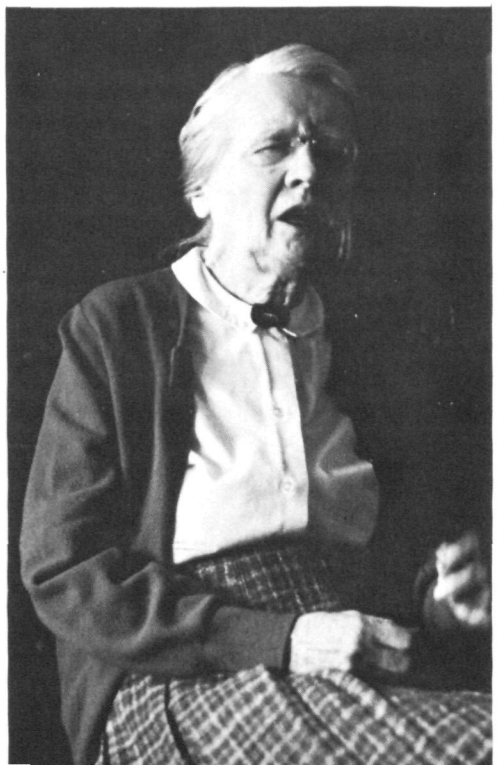
Miss Lucy Smith still lives in the Rockville home where, in 1891, her father established and operated the Coast Survey's first astronomical observatory

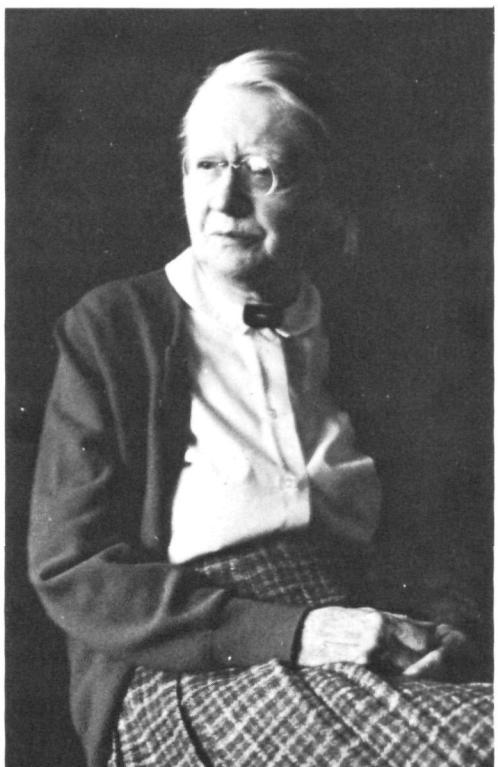
Although she left the federal government in 1957 after 39 years with the Veterans Administration and its predecessor agencies, she said she hasn't "really retired." She remarked: "There's been one bunch of kids after another in this house, and they've kept me hopping." Nineteen children have lived there in the intervening years. She's active in various organizations, including the Montgomery County Historical Society, the Young in Heart, a senior citizens group, the Rockville Women's Club, the Rockville Garden Club and, until a short time ago the recently disbanded Inquiry Club, of which she is the only living charter member.

Memories of her father and mother abound in the old structure with the wide veranda. On one wall of the library are pictures of her father and his forebears; on the other, those of her mother. In various cabinets, chests, and boxes are mementoes of her father's life, of his trips to Alaska, Guam, the Philippines, New Zealand, Australia, Malaysia, and Japan, including a piece from the Trans-Pacific cable when it was extended to Guam in 1904 and the beautiful chinaware he brought back from Tokyo. And his library, which had belonged also to his father, the books and pamphlets worn from frequent use.

In the rear of the old mansion is a nondescript little building which housed the Coast and Geodetic Survey's first astronomical observatory for the study of the variation of latitude. Used now for storage, it still stands as a monument to his work







on the wobble of the earth on its polar axis, a study which is continued today by NOAA observatories in Gaithersburg, Md., and Ukiah, Calif., and by other astronomers around the world.

In the observatory which he established in his garden, Edwin Smith spent the nights (when the sky was not overcast) from June 13, 1891, until July 9, 1892, plotting the course of the stars. It was from these data and those collected by other latitude observatories that scientists have been able to measure the extent of the earth's wobble on its polar axis. As yet, the cause of the wobble has not been determined; neither has its effect, if any, on the earth, although some seismologists believe it is connected with earthquakes.

Smith at this time was Chief of the Instrument Division at the Capitol Hill headquarters of the Coast and Geodetic Survey. When the International Geodetic Association requested that the Survey cooperate in research on variations of latitude, the Superintendent "instructed" Smith (according to the Superintendent's annual report to Congress for the fiscal year ending June 1891) to establish an observatory and make the necessary observations. Smith's home happened to be in the right place for an observatory.

"In pursuance of these instructions, Mr. Smith put up a temporary observatory near his residence at Rockville and, after some delays due to great pressure of work in the Instrument Shop of the office, he mounted the zenith telescope by the end of May and began regular observations June 13," the Superintendent reported.

Smith's nightly observations, which the Superintendent pointed out were "in addition to his regular duties as Chief of the Instrument Division," were "voluntarily assumed," the Superintendent made clear in his annual report. According to his daughter Lucy, Smith was then regarded as a wealthy man, with a salary of $2000 a year, so presumably there was no need to pay him for his "voluntary" nightly observations of the heavens.

(Above) Edwin Smith, who served the Coast and Geodetic Survey as an astronomer and geophysicist from 1870 to 1912, built this 16-room home in Rockville, Md., for his family in 1890. In the rear of the old mansion is the building that housed the agency's first observatory for the study of latitude. Mr. Smith's daughter Lucy, now 83, still lives in the house. (Below) Edwin Smith as a young man.

During the year of observations that followed, Smith made nearly 1800 individual measures for latitude on 146 nights, many of them in bitter cold, for the observatory was not heated. The accuracy of the observations would have been affected adversely by heat.

After a year, Smith's regular work forced him to discontinue observations and the observatory was never used again. However, seven years later, Smith was entrusted with the task of establishing an observatory at nearby Gaithersburg, where it is still located. A man of considerable energy, he did so in 10 days. The next day, July 1, 1899, he assumed direction of the new observatory, conducting observations there until January 4, 1901, when he turned it over to another astronomer.

His work at Gaithersburg was also apparently voluntary, and unlike that at Rockville, he sometimes failed to get home at night. To enable him to keep in touch with his family, a phone was installed in the Rockville home. "It was one of the first phones in Rockville," said Miss Lucy. "It was put high up on the wall so we kids couldn't reach it.

"He had a little cottage in Gaithersburg by the observatory," she recalled. "It had a wood stove and was nice and cozy during the winter. There were two little rooms with bunk beds. We kids would go up there two at a time with our mother." (Miss Lucy was the Smith's only daughter, the second of six children. Her oldest brother will be 86 in November.)

Smith's daughter has fond recollections of the nights they spent in Gaithersburg. "Dad would let us look through the telescope when he wasn't busy. We loved to gaze at the moon. It looked like a beautiful piece of embroidery." Miss Lucy was then about 12.

The nightly observations of the heavens resulted in her father being referred to locally as "Mr. Astronomer Smith" to distinguish him from another Smith in the town. The observatories were quite an attraction. Her parents entertained frequently at their Rockville home, a popular spot for Coast Surveymen from Washington during hot summer nights. Guests often included Superintendent Thomas C. Mendenhall and his successor, O. H. Tittman. After dinner, Smith's guests would view the moon and stars through his telescope. When the observatory moved to Gaithersburg, "they would hire a bus and go there to gaze at the heavens," said Miss Lucy.

The bus was horse drawn, Miss Lucy recalled. "There was a livery stable in town," she said, "with two buses. Rockville was quite a summer resort until 1906 or 1907,

continued

and the buses were in demand. The smaller bus, pulled by one horse, seated six to eight people on benches along the side. The larger two-horse bus seated about 10 to 12."

Smith was well qualified for his nightly observing activities. Born in New York in 1851, he entered the Coast and Geodetic Survey from the College of the City of New York in 1870. "He evinced the aptitude for observation and research which in his forty years of service has linked his name with the most remarkable results credited to American Field Astronomy," said Superintendent Tittman following Smith's death in 1912. According to *Who's Who in America* for 1903-1905, Smith was self-taught in astronomy and geodesy.

"At the age of 23," recounted Tittman, "he was selected for the distinguished honor of Chief of Party to observe the Transit of Venus on Chatham Island (New Zealand) and again, in 1882, was sent to Auckland, New Zealand, in the same important capacity." Later, he determined the force of gravity, using as he did so the famous Kater pendulums of the Royal Society of England. This work took him to Auckland; Sydney and New South Wales, Australia; Singapore; Tokyo; San Francisco; and back to Washington.

"In 1903," continued Tittman, "this last work was fittingly supplemented by the personal share he took in the Coast and Geodetic Survey telegraphic longitude expeditions which, by observations at San Francisco, Honolulu, Guam, and Manila, furnished the first longitude net that was completed about the earth." In view of this, it was only natural that Smith was selected to establish the Rockville and Gaithersburg observatories and to conduct the first observations there.

Miss Lucy recalls her father's lengthy absences from home. On one occasion, he spent about 14 months in Guam and, on another, 18 months in Alaska. When he was away, he wrote his wife every day.

"My parents were very much in love," said Miss Lucy. "When my father was away from home, he wrote her every day." She did likewise. Where mail went out infrequently, he saved his letters and mailed them in one batch. In one of his letters from Alaska, Smith remarked how wonderful it was when the boat came in from the states and he received a number of letters from his wife.

Smith never really took to Alaska. He was impressed by its scenery, but had a dim view of its agricultural possibilities. The absence from his family and the general lack of companionship discouraged him.

"I am getting tired of this place already," he wrote his wife from Sitka on June 16, 1905, "and I do not know what I would do if I had to live in such a place. It is dead and I do not think it will ever amount to anything. There is a lot of talk here about agriculture in Alaska (hot air). It amuses me very much indeed."

The high prices prevalent then (as now) in Alaska irked Smith considerably. Writing from Skagway a week later, he remarked: "I went to have my hair and whiskers cut and was dumbfounded when I was charged $1.00 for the job. I guess I will let them grow to a very great length before any of these frauds get another dollar out of me."

Subsequently, writing about the construction of an observatory he was supervising in Eagle, Alaska, at Fort Egbert, 12 miles from the Canadian border, Smith told his wife that there were two men working there "and between them they would get $13 per day." He added: "Prices up here are outrageous. Twenty-five cents is about equal to five cents at home. Five dollars is about the same as one dollar at home."

(Above) Smith in his office in Alaska in 1905, when he was supervising construction of an observatory at Fort Egbert. (Below) The original Rockville observatory as it is today.

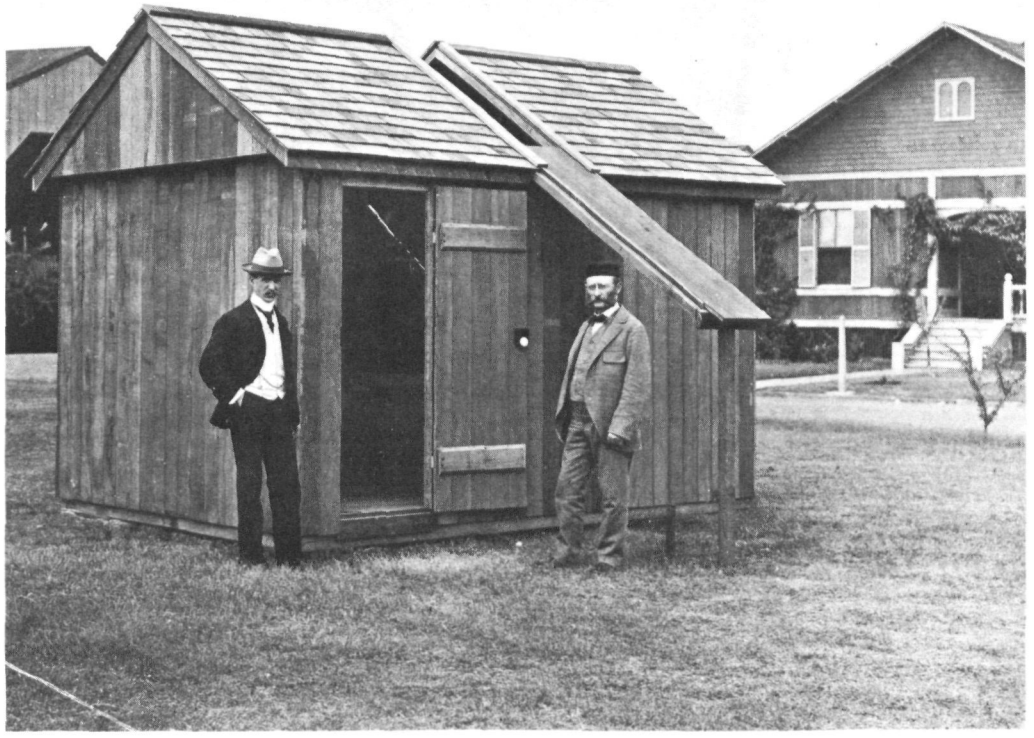
While in Eagle, Smith was able to economize on his expenses by living at the Army post at Fort Egbert. "If I were not at the military post," he wrote, "I do not see how I could manage at all. Four dollars a day would be the least I could live for and very poor living at that. Not as good as I could get in Washington for $25 per month." By living at the post, Smith added, he would be able "to save a little out of my allowance."

The high cost of living continued to impress Smith as he prepared to return home from Alaska later that year. Traveling through Yukon Territory, Canada, Smith found the prices "simply outrageous" when his Yukon River Steamer 'Hannah' paused for the night at Dawson.

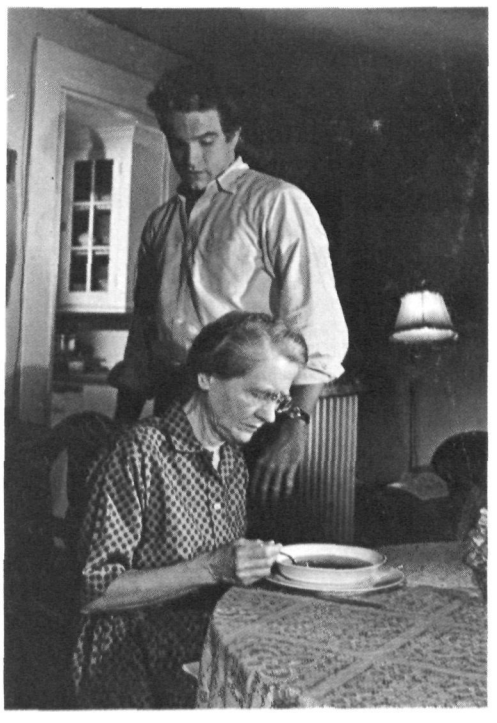
Smith stayed at the White House hotel that night. "I had to pay a dollar to get to this hotel with my suitcase," he wrote, "and I had to walk and carry the typewriter at that . . . I only pay a dollar for this room and it is certainly worth more than to carry a suitcase so short a distance."

Smith thought that if prices could be reduced, things might change in Alaska. "There are many attractive things in Alaska during the summer season," he wrote his wife, "and if traveling should be made more easy and less expensive, I do not doubt that many thousands would take the trip every year simply for pleasure. I doubt if more beautiful scenery can be found anywhere in the world."

But shortly thereafter, he expressed misgivings about the summer weather in Alaska. Writing from Fort Egbert on August 26, 1905, he advised his wife that "last night we had a snow storm which was quite heavy for this time of the year. . . . It is cold and the fires have to be kept up all day. It



(Above) Smith, at right, in 1903 at a Honolulu observatory, where he was determining the exact time difference between San Francisco and Honolulu. (Below) Miss Lucy Smith and actor Warren Beatty in a scene from "Lilith."



looks as if they were going to have an early winter." But the sun came out the next day, he added, and most of the snow vanished.

Food was in short supply at Fort Egbert, since it had to be shipped from the states by boat. On one occasion, when the boat arrived with commissary goods for the post, Smith, noting that the supplies included eggs, remarked: "I do not think I will want many of the eggs as they have been some three months getting here."

Entertainment included going to the local church to listen to the Sunday sermon and playing the victrola in the evening. "I stopped in at the doctor's," he wrote, "and he set his Victor Talking Machine agoing and we stayed until 11 p.m. It is the best of these machines I have ever heard and we enjoyed quite a concert. It is about the only music we have up here. . . . The Victor plays all sorts of music and some is quite good."

When the time finally arrived for Smith to return to his Rockville home, he wrote his wife he was going back to "civilization," and added: "There is no place like home and all the pleasures of travel and other companionships can never take the place of home and one's own family."

The home he loved so well was originally intended to be much smaller, Miss Lucy recalled. "My parents spent the summer of 1889 in Rockville because it was so hot in Washington and decided to build a summer home here. They planned to erect two cottages, but my mother, who was from New Orleans (where her father was president of the Cotton Exchange), wanted a veranda and a room for her mother. Dad decided he wanted something bigger also, so they built this house."

The one-and-a-half-acre lot and the house cost $6000 and the family moved into its new home in June 1890. Miss Lucy was then one year old and the community of Rockville had a population of 1568, which has since grown to more than 41,000. In 1890, the community ended about three blocks from the Smith home.

Smith left for his office, a 16-mile trip, on the 7:55 a.m. train from Rockville, walking a mile to the railroad station. Before he left, the closely knit family had breakfast together. Miss Lucy recalled that her father always started the day off at the breakfast table with prayers. He worked at his Washington office from 9 to 4, including a half hour for lunch, returning home in time for dinner at 6 p.m.

"My father was considered in Rockville to be a rich man," said Miss Lucy, "and a man of prominence because of his position with the government." The neighbors probably got the impression he was wealthy, said Smith's daughter, because her parents were able to employ a number of servants, including a cook, nurse, washerwoman, and a yardman.

"The cook received $8 a month," said Miss Lucy, "which was considered good in those days. Some people paid only $4 a month." The average income in Rockville was $60 to $75 a month, while Smith earned better than $166 monthly. This was in 1891 and Smith's superior, Dr. Thomas C. Mendenhall, Superintendent of the Coast and Geodetic Survey and a noted scientist, received $6000 a year.

Operating under Mendenhall in 1891 were some 40 assistants, including Smith, who were paid $1550 to $4000 a year. Among them, in addition to Smith, were men who later rose to prominence in the Coast and Geodetic Survey, including George Davidson, Charles S. Peirce, Otto H. Tittman, Richard M. Bache, John J. Gilbert, and Dallas B. Wainwright.

Others on the payroll in 1891 included a half-dozen sub-assistants who received $1200 to $1400 a year and four aids, paid about $900 annually. Stenographers and typists (the latter designated according to their instruments as "typewriters") received approximately $925 to $720 respectively, in some instances less than messengers, who were paid $820.

Smith's daughter remembers her father as a very friendly man, intensely interested in his work and in his family, who liked to talk about his activities in the Coast Survey and his travels.

He also was a very dedicated man, who refused to stop working even when stricken with cancer. "He was gifted with an endurance for mental and physical labor that acknowledged no fatigue," wrote Superintendent Tittman. "With his fatal illness already in evidence, he persevered in and completed an astronomical campaign in the wilds of the Copper River, Alaska; and when, after his return to Washington, he was apparently relieved by a serious operation in December (1911), in the following March he was again in the field, resuming operations in Western Texas."

On December 1, 1912, Edwin Smith died in the home he loved so well. He is buried in Rockville cemetery. Smith was a member of the Washington Philosophical Society and the Astronomical and Astrophysical Society of America and a founder of the Cosmos Club in Washington.

People passing the old Rockville mansion sometimes point to the house and recall that one scene from the movie "Lilith" was filmed there. But to Lucy Smith, it's the people who have lived there during the past four-score years and more that have made the old mansion what it is today, a monument to an important period in the history of the nation's oldest scientific agency and the role her father played in it. □

WHERE THERE'S FIRE THERE'S SMOKE

Smoked fish has long been a favorite with the American public. Usually, though, the smoking has been done by commercial smokehouses.

Now, home economists of the National Marine Fisheries Service have developed a new method of producing smoke-cooked fish on any outdoor barbecue equipment with a hood.

Although it is slower than ordinary grill cooking, smoke cooking adds special flavor and aroma and is particularly appropriate for fish and shellfish, because they are naturally tender, delicately flavored, and cook quickly.

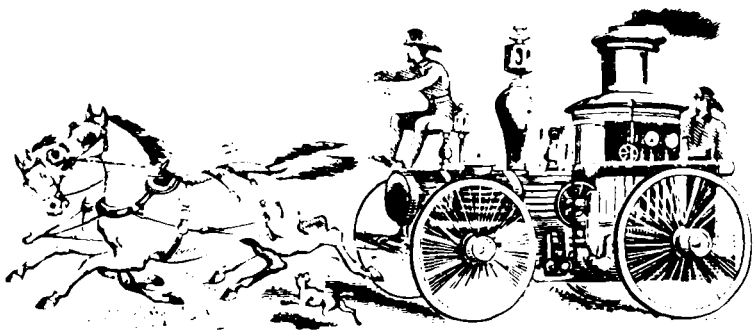
The following instructions and most of the recipes are from the NMFS National Marketing Services Office's new poster, "Where There's Fire There's Smoke," published as the outdoor cooking season opened.

A NEW METHOD OF FISH COOKERY

START BY HAVING THE

fish ready. Thaw if frozen. Check table for desirable forms.
Mix 1 gallon cold water with 1 cup salt;
Stir until dissolved.
Marinate fish in brine according to table.
Soak 1 pound of hickory or other hardwood chips in 2 quarts of water.
Now you are ready to start the fire.

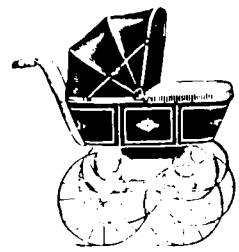
Size 'n Shape	How much to serve 6	How long to marinate in brine	Cook at	How long
Butterfly fillets (including bone, 1 pound each)	6 pounds	30 minutes	150°-175°F. 200°F. 250°F.	1 hr. + 30 min. 45 min. 30 min.
Fillets or steaks (½ inch thick)	2 pounds	30 minutes	150°-175°F. 200°F. 250°F.	1 hr. 30 min. 20 min.
Fillets or steaks (¾ inch thick)	2 pounds	45 minutes	150°-175°F. 200°F. 250°F.	1 hr. + 30 min. 30-45 min. 30 min.
Fillets or steaks (1 inch thick)	2 pounds	45 minutes	150°-175°F. 200°F. 250°F.	1 hr. + 45 min. 30-45 min. 30 min.
Fillets or steaks (1½ inches thick)	2 pounds	1 hour	150°-175°F. 200°F. 250°F.	2 hours 1 hr. + 15 min. 45-50 min.
Pan-dressed	3 pounds	30 minutes	150°-175°F. 200°F. 250°F.	2 hours 1 hr. + 15 min. 45-50 min.



ABOUT THE FIRE!

KEEP THE HEAT LOW, LOW, LOW

Use electric, gas, or charcoal grill with a hood or cover.
If charcoal, use fewer briquets than with average broiling fire.
When coals are red, spread evenly over bottom of cooker.
They should be sparse.
Cover ceramic or charcoal with ⅓ of the wet chips.
Wet chips produce smoke and lower the temperature.
If available, use oven thermometer with charcoal grill.
With gas or electric grill, adjust for desired temperature.



Little Things Mean A Lot

Excellent smoked fish can be produced on electric, gas, or charcoal grills. Adjust the temperatures according to recipes used. The procedure is the same.
Very low temperatures, 150°-175° F., are not absolutely essential in smoke fish cookery. Good results may be accomplished by using higher temperatures up to 300° F. Fish takes on a smoky flavor quickly, reducing cooking time.
Cooking time varies with weather, intensity of heat, amount of moisture in chips, type of grill, and distance of fish from heat.
Read all available information on your grill.
Serve with gusto'n goodies.

SHRIMP-OYSTER CREOLE

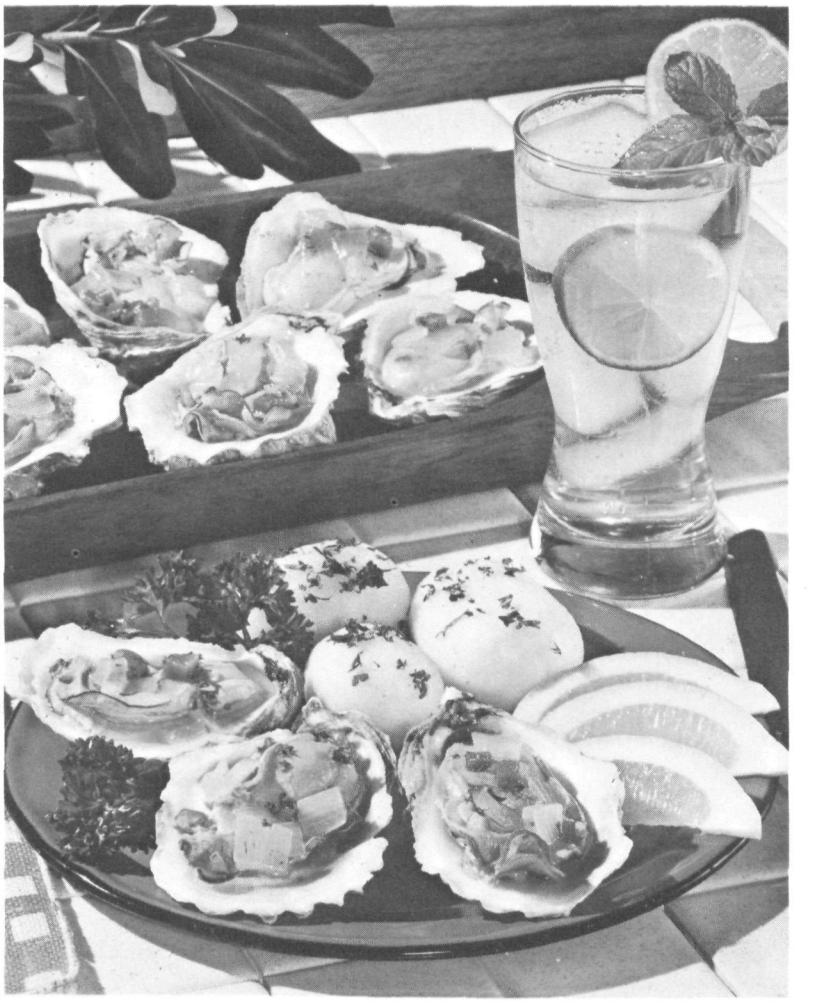
1 pound raw, peeled, cleaned shrimp, fresh or frozen
1 pint oysters, fresh or frozen, drained
6 slices bacon, diced
1 clove finely minced garlic
1 cup sliced onions
1 cup sliced celery
1 cup green pepper strips
1 bay leaf, crushed
1 teaspoon chili powder
¼ teaspoon pepper
1 teaspoon sugar
2 teaspoons salt
1 can (1 lb.) tomatoes
1 tablespoon vinegar
1 cup chicken broth
1 cup green peas, cooked
1½ cups precooked rice
Chopped parsley

Thaw frozen shrimp and oysters. Cook bacon until crisp. Add garlic, onions, celery and green pepper strips and cook until vegetables are tender. Add bay leaf, chili powder, pepper, sugar, salt, tomatoes, vinegar and chicken broth. Let simmer for 5 minutes, add peas. Put rice in bottom of well-greased 10-oz. individual aluminum foil containers. Place creole sauce on top of rice. Top with shrimp and oysters. Place container on grill inside smoke oven. Cook in a slow oven 300° F., 15-20 minutes or until shrimp are done and have a golden smoke color and the edges of oysters have curled. Garnish with chopped parsley. Makes 6 servings.

FISH-VEGETABLE MEDLEY

2 pounds fish fillets, fresh or frozen
2 teaspoons salt
¼ teaspoon pepper
2 (4½ oz. ea.) cans deviled ham
1 (1 lb.) can whole potatoes, drained
1 (1 lb.) can whole onions, drained
1 (8 oz.) box frozen mixed garden vegetables
3 tablespoons lemon juice
1 (10¾ oz.) can condensed tomato soup

Thaw frozen fish. Cut into serving-size portions. Cut six pieces heavy-duty aluminum foil, 12x12 inches each. Grease lightly. Place fish on each piece of foil. Season with salt and pepper. Spread deviled ham on top of each piece of fish. Divide remaining ingredients equally among the packages of fish, using the soup last. Bring the foil up over the fish and seal the edges by making double folds in the foil to confine the juices. Place the packages on the grill inside the smoke oven. Cook in a slow oven, 300° F., for 15 minutes; open packages by cutting a crisscross in the top of each package and fold the foil back. Continue to cook for 10-15 minutes longer until the fish flakes easily when tested with a fork and the ingredients have a smoke flavor. Makes 6 servings.

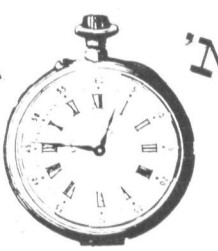


SMOKY OYSTERS SUPREME

36 shell oysters
½ cup melted margarine or cooking oil
¼ cup chopped onion
¼ cup chopped pimiento
2 tablespoons chopped parsley
½ teaspoon salt
½ teaspoon liquid hot pepper sauce
½ teaspoon Worcestershire sauce
½ teaspoon dry mustard

Shuck and drain oysters. Place oysters on deep half of shells. Saute onion in melted margarine or cooking oil until tender but not brown. Add remaining ingredients. Spoon sauce over oysters. Place oysters on grill in smoke oven, 300° F., and cook slowly for 20 to 25 minutes or until edges of oysters begin to curl. Makes 6 servings.
NOTE: Shucked oysters may be used if you have your own shells.

QUICK 'N EASY



SMOKED FISH PORTION SANDWICH

6 (3 oz. ea.) frozen fried fish portions
¼ cup melted margarine or cooking oil
6 buttered toasted rolls

Brush fish portions with melted margarine. Place on well-greased grill inside smoke oven. Cook in a slow oven, 300° F., for 15-20 minutes or until fish flakes easily when tested with a fork. Place fish portion on bottom half of buttered toasted roll and serve with Tartar Sauce. Makes 6 servings.

TARTAR SAUCE

¼ cup mayonnaise or salad dressing
2 tablespoons sweet pickle relish

Combine mayonnaise or salad dressing and sweet pickle relish. Chill. Makes 6 servings.

Now you are ready to start smoking the fish.
Drain and dry fish.
Measure a generous ¼ cup cooking oil. Keep pastry brush handy.
Grease grill well.
Place fish on grill, skin side down, about 4-6 inches from heat.
Baste fish well at beginning and frequently during cooking.
Do not let fish dry out.
Keep coals covered with plenty of well-soaked chips.
Follow table according to size and shape of fish.

THINGS

TO DO WITH PAN-SIZE FISH

SMOKED HERBED PAN-DRESSED FISH

6 small pan-dressed fish, fresh or frozen
1 (8-oz.) bottle Italian salad dressing
2 teaspoons salt
2 cups finely-crushed herb-seasoned stuffing mix
½ teaspoon oregano
¼ cup chopped parsley

Thaw frozen fish. Clean, wash, and dry fish. Place fish in a single layer in a shallow baking dish. Pour Italian dressing over fish and let stand 30 minutes. Remove fish from sauce and sprinkle with salt. Combine herb-seasoned stuffing mix, oregano, and parsley. Roll fish in herbed mixture. Place fish on well-greased grill inside smoke oven. Cook in a slow oven, 200° F., for approximately 1 hour or until fish flakes easily when tested with a fork. Makes 6 servings.

EASY DO BAKED HUSHPUPPIES

1 cup cornmeal
1 cup flour
1 teaspoon sugar
3 teaspoons baking powder
1 teaspoon salt
⅛ teaspoon cayenne pepper
¾ cup milk
2 eggs, beaten
½ cup chopped onion
¼ cup melted fat or oil

Sift dry ingredients together. Add remaining ingredients and stir only until blended. Place approximately 1 tablespoon batter into well-greased small muffin tin wells. Place muffin pans on sheet of aluminum foil the size of the pan to prevent overbrowning. Bake in a hot oven, 425° F., for 15-20 minutes or until done. Makes 44 hushpuppies.
NOTE: Use 1¼-inch diameter wells. Recommended for electric or gas grills only. May also be baked in conventional oven.

TIPSY DIXIE CATFISH

6 (½ lb. ea.) skinned, pan-dressed catfish or other small fish, fresh or frozen
1 gallon water
1 cup salt
½ cup beer
½ cup prepared mustard
2 cloves finely minced garlic
½ teaspoon Worcestershire sauce
¼ teaspoon liquid hot pepper sauce
½ cup sesame seeds, toasted
2 tablespoons chopped parsley
Paprika

Thaw frozen fish. Clean and wash fish. Add salt to water and stir until dissolved. Pour brine over fish and let stand for 30 minutes. Remove fish from brine and dry. Combine beer, mustard, garlic, Worcestershire sauce, liquid hot pepper sauce, ¼ cup sesame seeds and parsley. Dip fish in mustard mixture and sprinkle with remaining ¼ cup sesame seeds and paprika. Place on well-greased grill inside smoke oven. Cook in a very slow oven, 250° F., for one hour or until fish flakes easily when tested with a fork. Serve with hushpuppies. Makes 6 servings.

SOME LIKE IT HOT!

PLANTATION HOT SAUCE

½ cup honey
½ cup prepared mustard
½ cup cider vinegar
¼ cup Worcestershire sauce
2 teaspoons liquid hot pepper sauce
1 teaspoon salt
1 tablespoon chopped parsley

Blend honey and prepared mustard; stir in remaining ingredients. Heat to boiling. Serve with smoked fish or shrimp. Makes approximately 1½ cups sauce.

COOL BLENDER SAUCE

1 egg
1 teaspoon salt
1 teaspoon sugar
1 teaspoon mustard
2 drops liquid hot pepper sauce
Dash pepper
1 teaspoon instant minced onion
3 tablespoons lemon juice
¾ cup mayonnaise
¾ cup salad oil
⅓ cup chopped parsley
1 clove garlic, minced
1 tablespoon horseradish

Put into blender the first nine ingredients. Cover, blend a few seconds, uncover, add oil slowly, keeping motor running. Blend until thick and smooth. Add parsley, garlic and horseradish and blend until you get a smooth sauce. Serve with smoked fish. Makes approximately 2¼ cups sauce.

SO YOU'VE GOT A BIG FISH

SMOKED FISH WITH WILD RICE-MUSHROOM STUFFING

1 (3 to 4-lb.) dressed snapper, or other large fish, fresh or frozen
2 teaspoons salt
¼ teaspoon pepper
4 slices precooked bacon
¼ cup thinly sliced green onion and tops
Wild rice-mushroom stuffing

Thaw frozen fish. Clean, wash, and dry fish. Sprinkle inside and out with salt and pepper. Stuff fish loosely. Close opening with small skewers or toothpicks. Place precooked bacon on top of fish and sprinkle with sliced onions. Place fish on well-greased grill inside smoke oven. Cook in a slow oven, 200° F., for approximately 1 hour and 30 minutes or until fish is done and flakes easily when tested with a fork. Remove skewers. Makes 6 servings.
NOTE: 6 pan-dressed fish could be used instead of the snapper. The cooking time would be approximately 1 hour.

WILD RICE-MUSHROOM STUFFING

1 (4 oz.) package wild rice
4 tablespoons margarine or cooking oil
½ cup chopped onion
½ cup chopped celery
1 (2½ oz.) jar sliced mushrooms
¼ cup chopped parsley
¼ teaspoon pepper

Cook wild rice according to directions on package. Saute vegetables in margarine or cooking oil until vegetables are tender. Combine all ingredients and mix thoroughly. Makes approximately 2½ cups stuffing.

SMOKY SHRIMP POTATO SALAD

1½ pounds raw, peeled, deveined shrimp, fresh or frozen
4 cups thinly sliced potatoes, cooked
6 slices bacon, diced
1 cup sliced celery
1 cup chopped onion
1 cup green pepper strips
2 tablespoons flour
1½ teaspoons salt
3 tablespoons sugar
½ teaspoon celery seed
½ teaspoon paprika
1 cup water
½ cup vinegar
¼ cup chopped pimiento
¼ cup chopped parsley

Thaw frozen shrimp. Place potatoes in six well-greased, disposable aluminum containers. Place shrimp on top of potatoes. Cook bacon in frypan until lightly browned and crisp. Drain bacon on absorbent paper and reserve. Cook celery, onion, and green pepper in bacon drippings until tender. Stir in dry ingredients. Add water and vinegar and cook until mixture is thick; add pimiento and reserved bacon bits. Spoon sauce over potatoes and shrimp. Place containers on grill inside smoke oven and cook at 300° F., for 15 to 20 minutes or until shrimp are done and have a smoke flavor. Garnish with chopped parsley. Makes 6 servings.

SPREAD IT ON

SMOKED FISH SPREAD

1½ pound smoked fish
2 teaspoons minced onion
2 teaspoons finely chopped celery
1 clove garlic, minced
2 tablespoons finely chopped sweet pickle
1¼ cups mayonnaise
1 tablespoon mustard
Dash Worcestershire sauce
2 tablespoons chopped parsley

Remove skin and bones from fish. Flake the fish well. Mix all ingredients together and chill at least one hour. Makes approximately 3½ cups.

Advanced Experimental Buoy Stationed In Gulf of Mexico For Two-Year Test

The first of NOAA's series of advanced experimental buoys for automatically gathering oceanographic and meteorological data from the marine environment was stationed in the Gulf of Mexico in June.

The 100-ton buoy was anchored in almost two miles of water about 225 miles from Gulfport, Miss. It is scheduled to remain on site through 1974, transmitting environmental data.

The information from this instrumented platform and others that will follow is designed to fill an environmental data gap in maritime areas of the globe. Eventually, the establishment of a network of automatic buoys throughout the oceans, coastal waters, bays, estuaries, and large lakes will provide data required for predicting weather, sea conditions, fish migration, and other conditions with an impact on man and his endeavors.

The program to develop a national system of environmental data reporting buoys is being conducted by the National Data Buoy Center, headed by James W. Winchester. The instrumented platforms are prepared for testing at the Center's facilities at the National Aeronautics and Space Administration's Mississippi Test Facility, Bay St. Louis, Miss.

Six of the large buoys are scheduled to be stationed in the Gulf for test and evaluation. They are designed to withstand 150-knot hurricane winds, 60-foot waves, and 10-knot currents. Each platform can carry more than 100 sensors to measure and report oceanic and atmospheric conditions.

The buoys are transported and anchored by the Coast Guard Cutter ACUSHNET, based at Gulfport. The Coast Guard is providing the necessary servicing and maintenance support for the buoys at sea and communications services at the Coast Guard Radio Station in Miami, Fla. The shore receiving station relays the environmental data received from each buoy every three hours or on demand to NOAA's National Meteorological Center in Suitland, Md. Engineering data is transmitted to the National Data Buoy Center in Bay St. Louis.

Douglas L. Brooks Takes NACOA Post

Douglas L. Brooks, Special Assistant to the Director of the National Science Foundation since 1969, has been named Executive Director of the National Advisory Committee on Oceans and Atmosphere (NACOA).

NACOA, a group of 25 private citizens with a broad range of expertise appointed by President Nixon in 1971, is responsible for assessing all federal programs in

Earthquake Information Center Moves To New Boulder Quarters

The National Earthquake Information Center, formerly in Rockville, Md., began operations in Boulder, Colo., June 12, where it taps into a much improved source of earthquake data for the highly seismic western United States.

Part of the Earth Sciences Laboratories, the Center is almost entirely automated in its new location, and receives seismic signals over telemetry links from stations in California, Nevada, Utah, and Colorado, including one in Boulder.

These links are provided by the Earth Sciences Laboratories' Special Projects Party in Las Vegas, Nev., the Earthquake Mechanism Laboratory, in San Francisco, Calif., and by organizations cooperating in a western seismic data exchange. Colorado data comes from a network operated cooperatively by NOAA and the Colorado School of Mines, in Golden.

In its former location, the National Earthquake Information Center received continuous data from only one three-station network in the Washington, D.C., metropolitan area. Now Center seismologists have eight lines coming in from the western networks, permitting them to locate earthquakes down to about Richter magnitude 5 over the entire western United States, and down to still smaller magnitudes in many areas.

The new operations room of the National Earthquake Information Center is banked by instruments providing continuous visual recordings of incoming signals, and two devices which automatically convert seismic signals into photographic seismic records. A teletypewriter circuit connects the Center with other operations, worldwide. The Center receives seismic information over this circuit from hundreds of NOAA-managed and independent stations around the globe. An alarm system in the Center's instrumentation alerts the duty seismologists when an earthquake of Richter magnitude 6.5 or greater is detected anywhere in the world.

A computer terminal links the Center with a NOAA computer, programmed to find earthquake epicenters (surface locations), depths, and other data within minutes after the event has occurred.

The National Earthquake Information Center was created on August 15, 1966. Its 24-hour-a-day earthquake watch has provided scientists, the general public, and disaster-relief agencies with timely data on important earthquakes, and has transformed what was once primarily a data-processing operation into an information-centered one, extending its activities into such research areas as seismicity studies and estimates of seismic probability.

Douglas L. Brooks (continued)

marine and atmospheric sciences. In particular, the Committee reports annually to the President and to Congress on the status of the national effort in these fields, and advises the Secretary of Commerce on NOAA's operations and programs.

While he was with the NSF, he coordinated its oceanography program, was Executive Secretary of its Executive Council, and most recently assisted the Director in coordinating NSF staff studies in support of National Science Board policy and planning activities.

In 1963, he was appointed President of The Travelers Research Corporation (then The Travelers Research Center), of Hartford, Conn., of which he had been Vice President and Director of the Mathematical Sciences Department.

A 1938 graduate of Yale University with a B.S. degree in physics, Dr. Brooks holds M.S. and Sc.D. degrees in meteorology from Massachusetts Institute of Technology.

Radio Telescope Array Developed By NOAA Labs

A radio telescope array which observes radio stars and upper-atmosphere discontinuities simultaneously has been developed by the Space Environment Laboratory.

The instrument is so economical, with a hardware cost of approximately $1,000, that it should bring important new radio astronomical and ionospheric studies within the reach of universities and private researchers.

The array consists of 16 small zigzag antennas with a signal-combiner. Conceived for the purpose of studying small-scale irregularities of the ionosphere, it was designed and developed by Dr. Clifford L. Ruffenach, Dr. Willard M. Cronyn, and Kerry Neal.

The new NOAA radio telescope design represents an advance in observational flexibility. Each element is triangular in shape with a wire zigzagging from the narrow top to the broad base. A radio wave coming down over the triangle is picked up by an appropriate length of the zigzag wire whose active portion is about one-third of the radio wavelength. Different wavelengths may be picked up by different lengths of wire simultaneously. The present array can receive radio wavelengths between 3 and 12 meters. It is expected to be useful for a wide range of applications ranging from studies of the solar wind to radio emission from various natural radio sources such as the sun, Jupiter, and radio stars.

West Virginia Gets Weather Service Automatic Flash Flood Alarm System

The first of a new series of automatic flash flood warning systems was placed in operation at Wheeling, W.Va., in May by the National Weather Service.

The new flash flood warning system has three main elements, linked together by electrical circuitry: a robot water-level sensor at an up-stream point on the river; an intermediate station several miles or more downstream to provide electric power to the sensor; and a community-alarm station from which warnings can be spread quickly to the public.

The Weather Service plans to install seven additional automatic warning systems within the next two years at locations in the eastern United States where fast-rising flood waters from heavy rains are a chronic threat. There already are signed agreements for three such systems in Green Brook, N.J. (near Plainfield); Wayne County, Ohio (near Wooster); and Waynesboro, Va. (which is in the area deluged by Hurricane Camille). Negotiations are underway for an additional system in West Virginia, and others in the Carolinas and Maine.

Gulf Stream Eddy Studied By NOAA Oceanographers

Oceanographers have been keeping watch for more than a year over an unusual cold water eddy nearly 100 miles in diameter which broke through from the Gulf Stream and has been moving south along the Atlantic coast. The eddy was detected in April 1971 off Cape Hatteras, N.C., from infrared measurements made by the NOAA-1 spacecraft.

Nearly circular and revolving counterclockwise, the eddy is colder than the surrounding water and differs markedly from the few other Gulf Stream eddies that have been observed in that it has been moving in a comparatively straight line down the coast. Other eddies have been observed moving out to sea.

The Gulf Stream is given to unpredictable fluctuations in its course. Oceanographers refer to these fluctuations from its average course as meanders. When part of a meander breaks off, an eddy is formed. Colder water north of the Gulf Stream becomes encircled by the warm Gulf Stream, producing a central cold eddy surrounded by warm Gulf Stream water.

Since the eddy was first detected, it has been kept under observation by NOAA satellite (until July 1971, when the satellite became inoperative) and intermittently by the ship TRIDENT of the University of Rhode Island, the Navy and the Coast Guard.

Oceanographers are especially interested in this eddy because it is the longest-lived eddy whose life history has been recorded and studied, it is located in the western Sargasso Sea where "no eddy has been tracked before" (and where only two others have been thoroughly documented), it is moving in a comparatively straight line, and because it is the first cold water eddy whose "death" it may be possible to monitor.

Firm Seeks Alternate Seal Harvest Methods

Battelle Institute, Columbus Laboratories, has begun preliminary work on a study of alternative harvesting techniques which could be used in the annual fur seal harvest on the Pribilof Islands off Alaska. The herds are administered by the National Marine Fisheries Service.

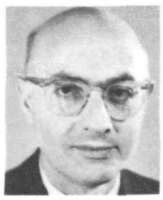
Although veterinarians and other experts have agreed that the technique presently used is a rapid, highly efficient and humane method of killing, NMFS has sponsored extensive research seeking improved methods of handling the harvest.

Under a $49,910 Federal contract, the research firm has agreed to make a detailed evaluation of a number of concepts that might offer potential improvements in harvesting techniques, develop one or more prototype killing devices, then test and evaluate them during the harvest on St. Paul Island this summer.

The contract stresses that any harvesting method developed must be painless, humane, employ minimal herding or driving, that it must be rapid, uncomplicated, and require a minimum of equipment and personnel. The procedure must not involve abnormal hazard to harvesting personnel, with no sacrifice in humaneness.

Carbon Dioxide Exchange Studied With ARL Model

A model of the exchange of carbon dioxide between the atmosphere, the oceans, and plant and animal life has been developed by Dr. Lester Machta, Director of the Air Resources Laboratories.



This model, together with estimates of man's future production of carbon dioxide through the burning of coal, oil, and natural gas, makes it possible to predict the atmosphere's carbon dioxide content in years to come.

Economic analyses suggest that worldwide fossil fuel consumption may continue to increase about four percent annually until 1980 and, as nuclear power production becomes more prevalent, three-and-a-half percent annually between 1980 and 2000.

Using these figures, Dr. Machta's model predicts that in the year 2000 the atmospheric carbon dioxide concentration will be about 20 percent greater than the 1970 figure of 322 parts per million.

Increasing carbon dioxide should raise the temperature of the lower atmosphere, because it permits solar energy to pass essentially unchanged into the lower atmosphere but traps the earth's radiation, creating what is called a greenhouse effect. During the past decade or more, the rising atmospheric carbon dioxide concentration has been documented on a global scale. But despite the expected warming, ground level air of the Northern Hemisphere has cooled since the mid-1940's. Therefore, it is clear, Dr. Machta says, that carbon dioxide is only one of the factors that determine the temperature of the lower atmosphere.

The new model of carbon dioxide exchange provides an improved tool for scientific study of man's inadvertent modification of the earth's climate.

Dr. Machta's model uses well-known physical processes to calculate the rate of exchange matter between the upper atmosphere (stratosphere) and the lower atmosphere (troposphere), and between the deep oceans and the sea's upper or mixing layer. It also incorporates ecologists' estimates of the amount of carbon taken from the air or the ocean in one year by growing matter, and of the length of time carbon is tied up in the biosphere. In the long-term biosphere—trees, for example—carbon is assumed to return to the air after 40 years when the wood decays. In the short-term biosphere — such as leaves—the carbon re-enters the atmosphere after two years.

The rate of exchange between the lower atmosphere and the upper ocean layer was derived from radioactive carbon-14 atoms produced by bomb testing. Dr. Machta found that the carbon-14 atoms had a mean residence time of five years in the atmosphere before entering the oceans.

The simple model—combined with past estimates and future predictions of fossil fuel consumption —has been used to calculate past and future carbon dioxide concentrations. The model showed that in the latter half of the 19th century the carbon dioxide content of the air was about 10 percent less than in 1970, while in the year 2000 it will become about 20 percent greater.

DISCO On Atlantic Expedition

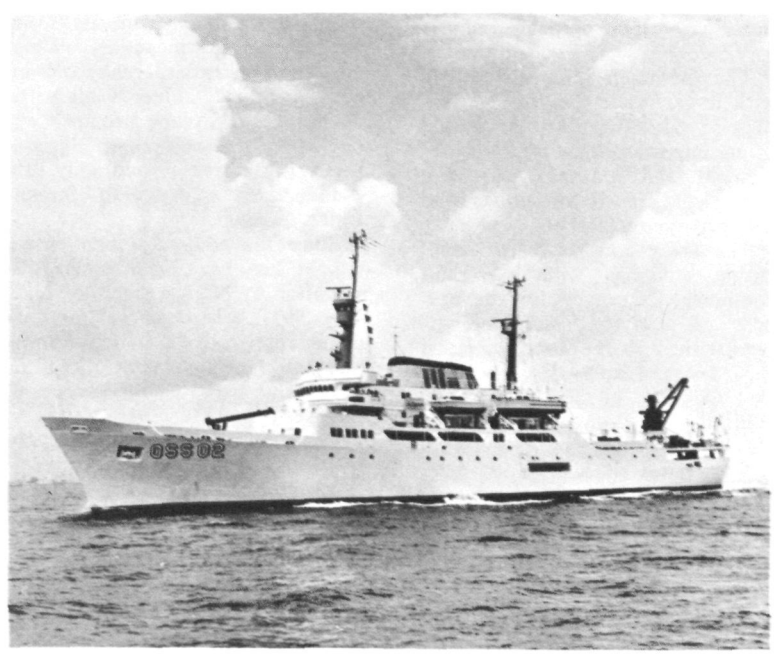
Scientists from four nations—United States, France, England, and Venezuela—spent April, May, and June aboard the NOAA Ship DISCOVERER, searching for new knowledge of the evolution of the Atlantic Ocean basin.

The expedition concentrated on geological and geophysical studies of the giant segments of the oceanic crust, called plates, in the area between the West Indies and the submerged mountain range known as the Mid-Atlantic Ridge. It also studied the characteristics of a number of small plates lying between the giant crustal segments of the North and South Atlantic Plates and the African Plate.

The expedition was conducted by the Atlantic Oceanographic and Meteorological Laboratories and the National Ocean Survey. Financial assistance was provided by the International Decade of Ocean Exploration program of the National Science Foundation.

The Caribbean-Atlantic area is believed to contain a number of small crustal plates, including the Caribbean Plate, whose boundaries were investigated by the expedition. The area is considered critical for this type of investigation since there exists in this comparatively small region of the globe a ridge-island arc system, major fault zones, and several major and minor crustal plate boundaries.

The expedition's chief scientist was Dr. George Peter of the NOAA Miami laboratories. Assisting him from the laboratories were Charles Lauter, Omar DeWald, George Merrill, Leroy Dorman, and George Lapiene. Other scientists aboard included C. Nakamura from the Woods Hole (Mass.) Oceanographic Institution; Genevieve Alla from the French National Center for the Exploitation of the Oceans (CNEXO); Graham Westbrook from the University of Durham, England; and two scientists from Venezuela.



Scientists from the United States, France, England, and Venezuela were on board the NOAA Ship DISCOVERER for a three-month study of the geological and geophysical characteristics of the Atlantic Ocean basin.

NMFS Sees Possibility Of Sea Urchin Fishery

The sea urchin—heretofore considered to be only a destroyer of productive kelp beds and a spiny menace to unwary waders—may be the basis of a new commercial fishery now being encouraged by the National Marine Fisheries Service. Development of the fishery could help solve an environmental problem in California coastal waters as well as provide an additional seafood delicacy.

With the assistance of scientists from the NMFS laboratory at Tiburon, Calif., two firms recently began processing red sea urchins on a trial basis, and testing their distribution facilities and sales potential for the roe, which is highly popular in France, Italy, Japan, Chile, and Hawaii. The roe reportedly brings excellent prices in Japan where demand has exceeded supply in recent years, causing dealers to import from new sources.

California has a tremendous sea urchin population. The urchins feed on seaweed, particularly kelp, which many marine animals depend upon for food and shelter, and some areas that once supported extensive kelp beds and a variety of sea life are now barren except for a thick carpet of urchins.

Previous kelp conservation efforts have been devoted to destroying sea urchins rather than utilizing them. In San Diego waters, an intensive project of this nature undertaken in the mid-1950's has resulted in the recovery of many kelp beds, which serve as habitat for many prized fish and shellfish. This research, located at California Institute of Technology, is presently co-sponsored by NOAA's National Sea Grant Program and the Kelco Company, a kelp harvesting firm.

Reduction of the sea urchin population through harvesting them for food also promises to help restore the abalone, a valuable marine animal taken for food by both sport and commercial fishermen. Scientists report that the sea urchin competes successfully with the abalone for food and space. Areas dense with urchins are usually devoid of abalones, and where abalones are present, they appear to be stunted.

To evaluate the effects of sea urchin removal from an area, NMFS biologists are working with the California Department of Fish and Game to study the sea urchin-abalone relationship in the Avila Beach area.

Air Pollution Monitoring Through Sound Studied

A system designed to modernize the observing and forecasting of air pollution conditions through the use of sound is being tested by the Wave Propagation Laboratory.

The acoustic echo sounder provides continuous observations of the height and undulations of the atmospheric inversion, a region of cold air topped by a warm layer that traps and concentrates pollutants. The NOAA scientists hope that the acoustic sounder can help recognize the onset of severe pollution episodes, perhaps as far ahead as the previous afternoon.

Directed by Dr. Freeman F. Hall, Jr., the experiment is being carried out in Denver at a site provided by the city to the National Weather Service.

The acoustic sounding technique is based on the fact that the propagation of sound waves depends on compression and rarefaction of air molecules. Thus, the condition of the atmosphere affects the transmission of sound—as much as a million times more strongly than it affects the transmission of meteorological radar waves.

The Wave Propagation Laboratory's acoustic sounder is a relatively simple instrument consisting of a horn-shaped loudspeaker/microphone that sends pulses of sound into the atmosphere. These high-pitch "pings" bounce off heated blobs of air, and some of the sound energy returns to the microphone. Recorded on a moving strip chart, the intensity variations of such backscattered sound continuously show the temperature structure of the lower 1500 feet of the atmosphere as it flows above and past the sounder.

In operation since December 1971, the experimental sounder is being used in conjunction with balloon-borne radiosondes. The Weather Service launches two slow-ascent radiosondes a day to monitor the inversion height up to 10,000 feet.

At present, acoustic sounding cannot replace the ascending radiosonde because the latter instrument observes temperature, humidity, and wind, all of them critical in air pollution control work. The acoustic device observes the thermal structure of the lower atmosphere, but not temperature itself. What it does, in contrast to the conventional radiosonde, is continuously monitor motions as well as the thermal structure of the inversion. This can help meteorologists to observe the formation of inversions, see the development of instabilities, and forecast inversion breakup.

"Eventually, we hope to use the acoustic sounder for reading the temperature itself, for observing the temperature profile of the inversion, and for mapping the lower atmosphere's humidity structure," says Dr. Hall, "I believe we can do this by using several sound frequencies simultaneously, sort of a 'chirp' instead of a 'ping.'"

Dr. Hall also plans to start wind velocity observations in Denver by tilting the acoustic sounder down to a 45-degree angle and measuring the frequency shift of the backscattered sound. An increase in frequency indicates the wind is approaching and a drop indicates the wind is moving away. The amount of the frequency change, or Doppler shift, can be converted into miles per hour.

An array of three acoustic sounders is the next step—two of them angled at 45 degrees and one vertically. In effect, this elaborate arrangement will provide fuller and more accurate three-dimensional information.

The Equipment Development Laboratory of the National Weather Service's Systems Development Office has also pursued ground-based remote sensing since the middle sixties, and is operating a very powerful acoustic sounder at Sterling, Va.

Dr. William H. Quinn Takes Post at NWS

Dr. William H. Quinn has been appointed to the new post of National Weather Service Assistant Director for Oceanography. Dr. Quinn heads the Weather Service's Office of Oceanography and is responsible for obtaining, processing, and disseminating the oceanographic data the Weather Service needs to provide real-time predictions for ocean phenomena that fall within NOAA's purview. A prime element of his new assignment is to administer the tsunami-warning service for NOAA.

Dr. Quinn comes to the Weather Service job from a position as research scientist in meteorology and oceanography at Oregon State University, in Corvallis, Oreg., where he has been on the faculty since September 1967. He holds degrees in geology and oceanography and had a 21-year career as an Air Force meteorologist, before his employment at Oregon State.

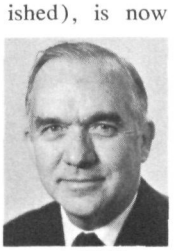
Born in Syracuse, N.Y., Sept. 28, 1918, he received a bachelor's degree in geology from Colgate University in 1940, a master's degree in geology from the University of Missouri in 1942, a master's in oceanography from Scripps Institution in 1951, and a doctorate in physical oceanography at Oregon State in 1967. He also studied meteorology at New York University.

Rear Admiral Allen L. Powell was sworn in on May 18 as Director of the National Ocean Survey by Dr. Robert M. White, NOAA Administrator, as Mrs. Powell looked on. The Survey's former Director, Adm. Don A. Jones, retired April 30.

NOS's Geodetic Survey Details Reorganization

The National Geodetic Survey was reorganized recently to consolidate all management, administrative and support activities in the Office of the Director.

Captain John O. Phillips continues as Director. Captain Leonard S. Baker, formerly Chief, Geodesy Division (which has been abolished), is now Deputy Director.



CAPTAIN JOHN O. PHILLIPS

CAPTAIN LEONARD S. BAKER

Dr. Hellmut H. Schmid continues as Director of the Geodetic Research and Development Laboratory and Commander J. Austin Yeager as Chief, Satellite & Marine Applications Division (formerly Satellite Triangulation Division).

New divisions and offices established were: a Support Staff, headed by M. L. Cutler; a Horizontal Network Division, headed by B. K. Meade, with J. F. Dracup as assistant chief; a Vertical Network Division, headed by S. P. Hand, with C. F. Ellingwood as assistant chief; a Gravity and Astronomy Division, with D. A. Rice as chief; and a National Geodetic Survey Information Center, with C. F. Kelley as Director. The National Geodetic Survey Operations Center remains in Kansas City, Mo., with Captain Gerald L. Short as Director. All field personnel are now assigned to the NGS Operations Center, which provides logistic and administrative support.

all in the family

PERSONNEL NOTES

Takashi Miyahara, general superintendent of Wakefield Fisheries of Alaska for the past nine years, has been named Chief of the National Marine Fisheries Service Office of State-Federal Relationships. He worked in the Bureau of Commercial Fisheries (now NMFS) from 1953 to 1962.

Lasaro R. Maipi is the new Official in Charge of the Weather Service Office at Truk, Eastern Caroline Islands. His appointment is the culmination of a program begun two decades ago to train Micronesians to take over the observational program at weather offices in the Trust Territory of the Pacific Islands.

Rheinhart W. Harms, formerly Meteorologist in Charge at the Milwaukee, Wisc., Weather Service Office, has been named MIC at the Atlanta, Ga., Weather Service Forecast Office.

Martin Ross is now Meteorologist in Charge at the Weather Service Office in Atlantic City, N.J. He formerly was Principal Assistant at the same office.

Preston Smith, who is on the staff of the Associate Administrator for Marine Resources, was recently elected Chairman of NOAA's Equal Employment Opportunity Committee.

Harold L. Miller has been named Acting Chief of the National Geodetic Survey's field party G-23.

Lieutenant Charles H. Langdon is the new chief of the National Geodetic Survey's gravity party G-52.

Robert E. Cardinal, former Official in Charge of the Green Bay, Wisc., Weather Service Office, has been named Meteorologist in Charge of the Yakima, Wash., Weather Service Office.

Commander Ralph J. Land, Projects Officer at the NOAA Atlantic Marine Center in Norfolk since January, has been appointed Commanding Officer of the NOAA Ship PEIRCE.

Commander James P. Randall is the National Ocean Survey's new Deputy Associate Director for Aeronautical Charting and Cartography. He was formerly Technical Assistant to the Associate Director, Aeronautical Charting and Cartography.

E. M. MacCutcheon, Marine Affairs Advisor to the Director of the National Ocean Survey, is a co-author of "Coastal Zone Management: Multiple Use With Conservation." Based on lectures in the University of California Engineering and Physical Sciences Extension Series, the book recently was published by John Wiley and Sons, Inc.

Aaron Woodard and **Dorothy Burke** have been selected for the ADMIN Fellowship Program. Mrs. Burke is currently an Administrative Officer with the Air Resources Laboratory of the Environmental Research Laboratories and has a target position in the budget field. Mr. Woodard, a Supervisory Computer Technician in the Operations Section, National Environmental Satellite Service, will have a target position of computer specialist.

Earl W. Rayfield, Mel Greenwood, and **William C. Irving** hold new posts in the National Ocean Survey's Office of Fleet Operations at Rockville, Md. Mr. Rayfield is Chief of the Operational Support Branch in the Operations Division; Mr. Greenwood is Staff Assistant to the Associate Director for Fisheries Resources; and Mr. Irving is Plans and Programs Officer.

Jack E. Fancher, Oceanographer in the Processing Section, Tides Branch, of the National Ocean Survey's Oceanographic Division in Rockville, Md., recently completed his master of science degree in marine sciences at the University of Puerto Rico, Mayaguez Campus.

Captain Hubert W. Keith, Jr., has assumed the duties of Deputy Director for Administration at the National Ocean Survey's Atlantic Marine Center in Norfolk, Va. He was formerly in charge of the Miami Ship Base. Commander Robert W. Franklin, formerly Chief of the Anchorage (Alaska) Field Office, is now in charge of the Miami Ship Base.

Hazel Tatro, who has headed the weather station at Greensboro, N.C., since 1965, has been named to head the expanded weather service program of the National Weather Service Office for the Bristol - Johnson City - Kingsport, Tenn., area.

Captain John B. Watkins, Jr., who, for the past two years has headed the National Ocean Survey's Honolulu Office, has been appointed Commanding Officer of the NOAA Ship SURVEYOR.

Commander Walter L. Bradley is now chief of the Processing Division at the National Ocean Survey's Pacific Marine Center in Seattle, Wash.

Commander Donald R. Tibbit is the new Chief of the Requirements Branch at the National Ocean Survey's Marine Chart Division. He served previously as the Commanding Officer of the NOAA Ship McARTHUR.

Commander Bruce I. Williams, former Commanding Officer of the NOAA Ship PEIRCE, has been named Chief of the Special Projects Branch at the Office of Fleet Operations at National Ocean Survey headquarters in Rockville, Md.

Lieutenant Commander Ned C. Austin has been named to head the National Ocean Survey's Hydrographic Field Party 742, a 12-member group which investigates navigational hazards along U.S. coasts.

Lieutenant Commander Walter F. Forster II is the new Executive Officer of the NOAA Ship DAVIDSON. He recently completed a tour of duty as Operations Officer of the FAIRWEATHER.

Lieutenant John O. Rolland has been named Assistant to the Chief of the Marine Chart Division at the Rockville, Md., headquarters of the National Ocean Survey. He was previously Field Operations Officer on the NOAA Ship PEIRCE.

Otis A. Cason, who has been Director of the Field Engineering Support Division for the U.S. Naval Oceanographic Office's Ocean Engineering Instrumentation Department for the past eight years, has been appointed manager of the National Ocean Survey's Gulf Coast Regional Center in Bay St. Louis, Miss.

Young T. Sloan, former Principal Assistant in the Forecast Center at Little Rock,, Ark., now heads the new Weather Forecast Center at Lubbock, Tex.

Dr. R. B. Matthiesen, who for the past 10 years has been on the engineering faculty at the University of California at Los Angeles, has been appointed Director of the Seismological Field Survey, headquartered in San Francisco, Calif.

Captain Floyd J. Tucker, Jr., who for the past two-and-a-half years has been Operations Officer at the Atlantic Marine Center in Norfolk, Va., has been named Commanding Officer of the NOAA Ship DISCOVERER.

David L. Coveney, Meteorologist in Charge of the Weather Service Forecast Office at New York City since 1969, is now Chief Operations/ Deputy Director of the NWS Eastern Region.

Herman F. Mondschein is the new Hydrologist in Charge of the River Forecast Center in Kansas City, Mo. He had been Principal Assistant at the RFC since his transfer in 1962 from the St. Louis RFC.

Harris Magnusson, fishery technologist with the Technical Assistance Division of NOAA's Office of International Affairs, has been assigned to an 18-month tour of duty in Saigon, Vietnam. He will work with the Department of State's Agency for International Development and the Vietnamese Directorate of Fisheries, mostly in industrial development and processing areas.

Lieutenant (j.g.) Warren K. Taguchi has been appointed Chief of Astronomic Party G-47 of the National Geodetic Survey.

Captain Robert E. Williams, who was the first Director to head the Lake Survey Center after it was transferred from the Army Corps of Engineers, has been reassigned to the NOAA Sea Grant Program at the University of Washington.

James Hansen and **Bryce Tilton,** Weather Service Specialists at WSMO, Quillayute, Wash., helped save the life of an automobile accident victim on March 22 while the early morning rawinsonde observation was in progress. They administered first aid to one of the accident victims who had been able to extricate himself from the demolished vehicle and find his way to the weather station; called an ambulance; and then rushed to the accident scene. They administered first aid to the second victim, who was trapped inside the car and bleeding profusely, until the ambulance arrived. The second victim survived, partly because of the response of Mr. Hansen and Mr. Tilton, who returned to the station in time to complete the observation and file a delayed report.

Commander Ray E. Moses, the new Tsunami Advisor to the State of Hawaii's Civil Defense, will also act as liaison between federal agencies and the state government. He is assigned to the National Weather Service's Pacific Region Headquarters to assist in the gradual transfer of the tsunami warning system from the Environmental Research Laboratories to NWS.

William C. George, Jr., formerly with the U.S. Civil Service Commission, has been named to head the Personnel Division's Personnel Relations Branch. Bernard D. Hull, who previously served as Assistant to the Chief, Personnel Division, is now Chief of the Division's Operations Branch.

Total 1971 Fish Catch Worth $643 Million

Commercial fishermen in the United States caught five billion pounds of fish, shellfish, and other aquatic animals and plants in 1971. The total catch was valued at $643 million at dockside—the highest dollar value in history. The value is up five percent from last year, and the volume increased one percent.

Landings for human food were 2.4 billion pounds in 1971, a decline of four percent from a year ago. Landings of fish used for industrial purposes, such as fishmeal and oil, increased by seven percent and reached 2.6 billion pounds.

Shrimp landings set a record, but tuna catches, excluding landings in Puerto Rico, were down 12 percent and salmon landings declined 24 percent compared with the previous year.

The figures are from *Fisheries of the United States, 1971,* a publication of the National Marine Fisheries Service.

Annual per capita consumption of edible fishery products in the United States declined from 11.8 in 1970 to 11.2 pounds in 1971. Edible fishery products plus those used for industrial purposes account for the equivalent of 57 pounds of fish (live weight) per person annually.

Gulf States' landings of menhaden, and industrial fish, and landings of shrimp along the Pacific Coast States, mainly Alaska, were the largest on record. Declines were noted in landings of anchovies, haddock, halibut, Pacific Ocean perch, swordfish, whiting, surf clams, and Dungeness crabs.

The value of fishery products processed in the United States from both domestic and imported raw materials was a record $1.85 billion—seven percent above 1970.

The 1971 figures show California as the leader in value of fish landed, $87.2 million; replacing Alaska which dropped to second place with $84.5 million; followed by Louisiana, $72.6 million; Texas, $70.0 million; Massachusetts, $46.0 million; and Florida, $45.2 million. The values given are dockside.

Louisiana again led all states in volume of catch, landing 1,396.2 million pounds; followed by California, 585.5 million pounds; Virginia, 489.0 million pounds; Alaska, 449.1 million pounds; and Mississippi, 397.6 million pounds.

Cameron, Louisiana, led all U.S. fishing ports in volume landed and San Pedro, California, led domestic ports in the value of the fishery landings.

Scientists Eye Jet, Climate Modification Linkage

Scientists of the Atmospheric Physics and Chemistry Laboratory are engaged in a 16-month research project that should help determine whether water vapor pumped into the stratosphere by the jet engines of supersonic transports and other high-flying aircraft will affect the climate.

The project, which began in March and will continue into the summer of 1973, consists of a series of flights northward to the subpolar regions, southward to the tropics, and east-west across the continental United States at altitudes ranging from 40,000 to 68,000 feet.

The purposes of the project are to establish the present season-by-season water vapor balance of the stratosphere and to determine how much water vapor is injected into the stratosphere by natural processes—such as thunderstorms, tropical upwelling, and jet streams—where it goes, and how long it stays there.

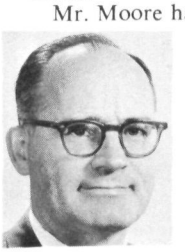
Dr. Peter Kuhn, responsible for the scientific portion of the project, has been observing water vapor in the high troposphere and the stratosphere since 1967 in a cooperative program with two National Aeronautics and Space Administration components, the Goddard Space Flight Center, Beltsville, Maryland, and the Ames Research Center, Moffett Field, California.

The Department of Transportation, with its interest in high-altitude commercial flight, added its support in 1971 to the joint research venture. DOT is contributing roughly $250,000, NASA $100,000, and NOAA $50,000.

This research is part of a larger NOAA program supported by NASA and DOT to investigate the balance of ozone and dust, as well as water vapor, in the stratosphere. The program is under the general direction of Dr. Earl Barrett. The ozone and dust work is the responsibility of Dr. Lothar H. Ruhnke.

Moore Fills Modification Post Created in NOAA Reorganization

Donald F. Moore has been appointed NOAA Assistant Administrator for Environmental Modification, a post established under a recent Department Organization Order.



Mr. Moore had served as NOAA Assistant Administrator for Policy and Plans since the agency's establishment in October 1970, and as Assistant Administrator for Plans and Programs of the Environmental Science Services Administration from 1968 to 1970.

In his new post, he is NOAA's policy officer for activities related to environmental modification—both intentional and inadvertent—and for NOAA's aircraft resources. He administers Department of Commerce responsibilities under the December 1971 Act of Congress requiring that all non-Federal weather modification activities in the United States and its territories be reported to the Secretary of Commerce.

Donald Moore was born in Clinton, Wisconsin, and attended Delavan High School, Delavan, Wisconsin. He enlisted in the Air Force in 1940 and was trained as a weather observer and forecaster. He was commissioned a second lieutenant in 1942, after attending Officer Candidate School.

His Air Force assignments included duty as inspector of weather facilities throughout the United States, as operations officer for weather squadrons in Japan and Germany, and as assistant weather officer of the Eighth Air Force, Strategic Air Command.

From 1950 to 1952, he worked in the Plans Office at Air Weather Service headquarters. He was then transferred to the Joint Chiefs of Staff in the Pentagon, where he was assigned as Secretary of the Joint Meteorological Committee. From 1959 until 1961, he served with the Air Force Systems Command as deputy director of research and development to improve the weather service.

He joined the Weather Bureau—now NOAA's National Weather Service—in 1963 as military advisor to the Chief of Bureau and acting chief of the Office of Planning.

Retiring from the Air Force in 1964 with the rank of colonel, he served as Deputy Federal Coordinator for Meteorological Services and Supporting Research, until his 1968 appointment as ESSA Assistant Administrator for Plans and Programs.

He won the Commerce Department's Gold Medal in 1971 for his outstanding leadership as NOAA Assistant Administrator for Policy and Plans.

Mr. Moore has studied at the University of Maryland, George Washington University, American International College, the Institute of Tropical Meteorology at San Juan, and various military institutes.

Gray Whale Census Shows Decrease

The number of gray whales counted during the annual southward migration was down about 15 percent this year from the average count since the National Marine Fisheries Service census began five years ago.

Between December 18 and February 8, two NMFS observers stood morning and afternoon watches to conduct the count, which takes place in daylight hours just south of Monterey, Calif.

The decrease does not necessarily indicate a decline in the gray whale population. Weather conditions, visibility, ocean currents, and other factors differ from year to year and could be responsible for the lower count this season.

NWS Doubles High-Seas Storm Information Service

Storm-information service for deep-water sailors in the Atlantic and Pacific was doubled in April, through a joint effort of the National Weather Service and the National Bureau of Standards.

The service previously had consisted of hourly broadcasts of about 45 seconds each, giving information about major storms causing hazardous conditions for ships at sea. The weather broadcasts are superimposed on time signals carried by NBS radio stations WWV in Fort Collins, Colorado, and WWVH in Kauai, Hawaii.

The new, expanded service, which began April 1, consists of two 45-second broadcasts, 1 minute and 15 seconds apart, and gives more information about more storms. The broadcasts are made around the clock. Station WWV carries information about storms in the Western North Atlantic and Gulf of Mexico. Station WWVH lists storms in the eastern and central parts of the North Pacific. Ocean areas involved are those for which the U.S. has warning responsibility under international agreements. The new broadcasts include, for the first time, data on the mid-latitude and tropical areas of both oceans.

If there are no storm warnings for the designated areas, the broadcasts so indicate. The brief messages are designed to tell mariners if there are storm threats in their areas—not to provide complete information. Mariners are expected to check with one of the regular marine broadcasts for details.

The photograph on the cover of the April 1972 issue of NOAA Magazine should have been credited to J. Miner, Monroe Evening News.

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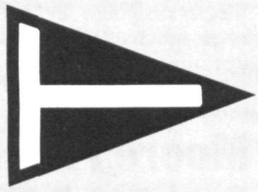
ATTENTION MARINE SPORT FISHERMEN!



Fly the tagging flag!

Tagging of marine game fishes is needed to discover the seasonal migration and distribution patterns of these prized game fishes. This information along with other life history facts is necessary for the sound conservation of these important resources. The Cooperative Marine Game Fish Tagging Program has concentrated on marlin and sailfish over the years, but many other species such as roosterfish, yellowtail, wahoo, and the tunas are studied.

The success of the program depends on the cooperation by *YOU*, the sport fisherman. Anglers are urged to further conservation by tagging and releasing their catch. Likewise, we urge you to watch for tags on the fish you catch and mail the tags to the National Marine Fisheries Service, Southwest Fisheries Center, La Jolla, California.

Tagging instructions and equipment are available at most major fishing resorts. For further information please contact:

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Center
P. O. Box 271
La Jolla, California 92037

Flags are flown more proudly for fish tagged and released than for those killed.

COOPERATIVE MARINE GAMEFISH TAGGING PROGRAM

U. S. NATIONAL MARINE FISHERIES SERVICE ▫ INTERNATIONAL GAME FISH ASSOCIATION ▫ WOODS HOLE OCEANOGRAPHIC INSTITUTION ▫ MEXICAN DEPARTMENT OF FISHERIES