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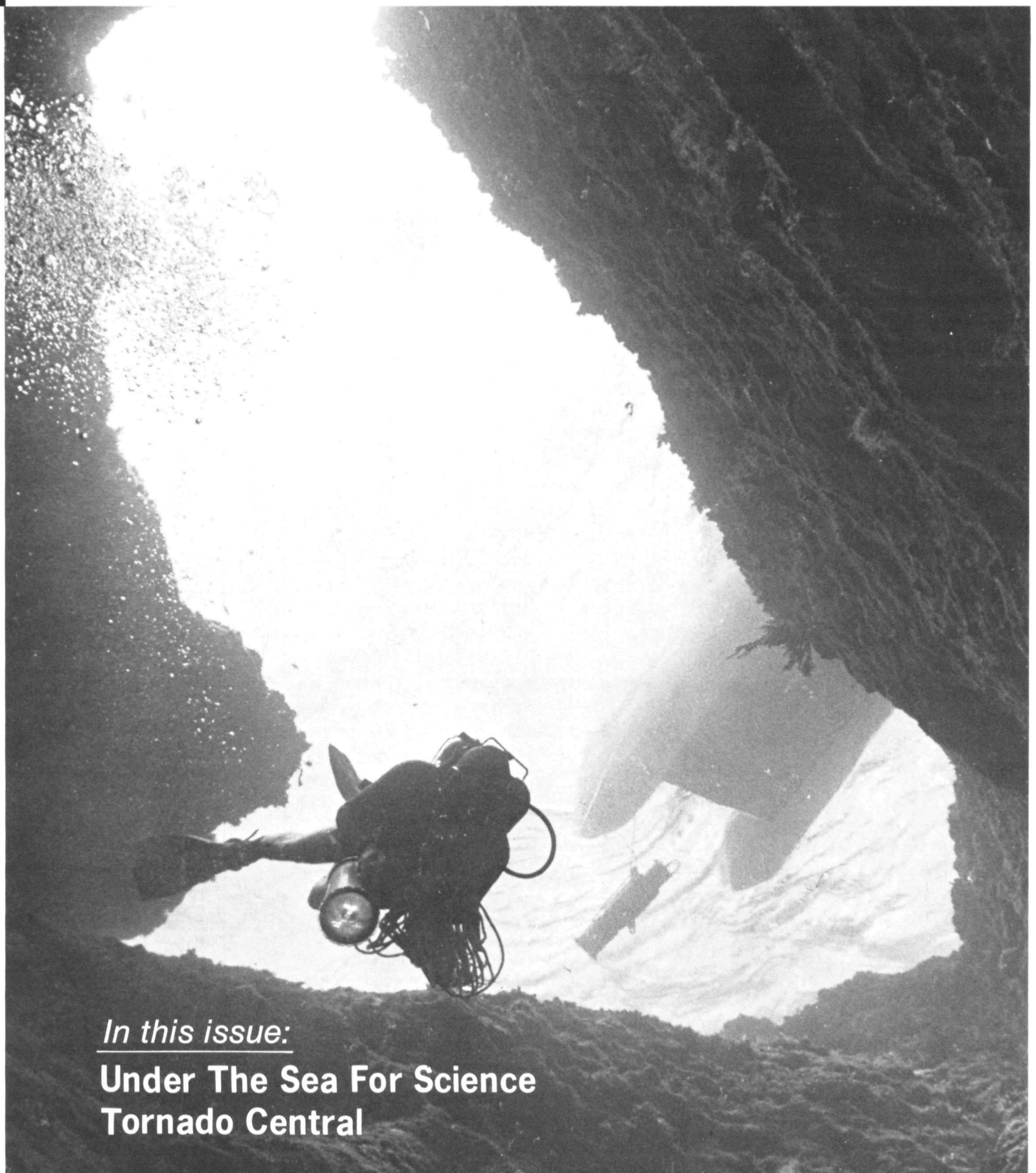
NOAA

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



In this issue:

Under The Sea For Science
Tornado Central

VOLUME 2
NUMBER 1

National Oceanic and Atmospheric Administration

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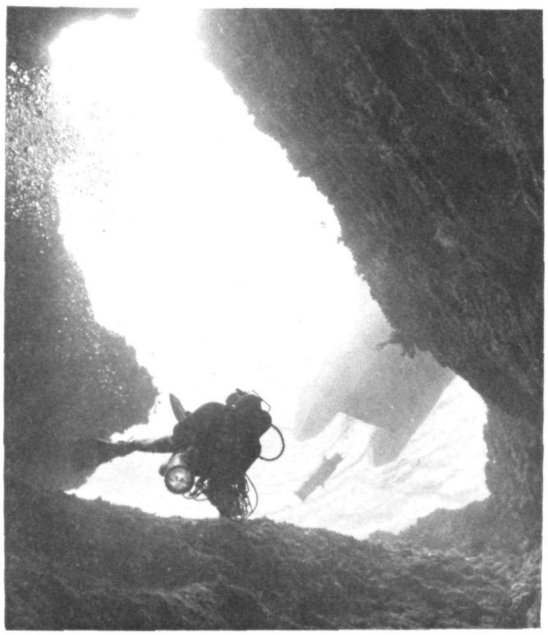
U.S. DEPARTMENT OF COMMERCE
Maurice H. Stans, Secretary

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

JANUARY 1972
VOLUME 2 NUMBER 1

Page

3. A Message From the Administrator
4. Under the Sea for Science *by Roland D. Paine, Jr.*
11. NOAA Space Command *by Ann K. Cook*
14. Chartmaker to the Nation *by Raymond Wilcove*
18. Tornado Central, U.S.A.
26. Man of Action *by Eileen Weppner*
29. Treasures of Barataria Bay *by Joline Faxon*
32. Supermodel *by Joann Temple Dennett*
35. Breaking the Air Traffic Jam *by Fred G. Bear, Jr.*
38. Requiem for the Pathfinder
40. Blizzard of '88 *by Patrick Hughes*
46. It All Began With the Ark *by Grace Wegner*
51. Shaping Up With Seafood
54. News From NOAA



COVER

With scuba divers, as well as habitats and submersibles, NOAA's Manned Undersea Science and Technology program has begun to explore the world beneath the oceans.

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A Message From the Administrator

ROBERT M. WHITE

NACOA comes into existence at a time when our environmental problems are of more pressing importance than ever before. It comes into existence at a time when our programs and plans, as we now begin to formulate them in the early years of our organization, can benefit greatly from the careful review, comments, and suggestions of such a body.

I have always found advisory committees to be one of the most underrated and, in many cases, least understood phenomena of government. They serve to keep us alive, alert, and responsive to needs, influences, and scientific developments which we sometimes fail to perceive because we are so close to our task and to our work. A useful advisory body can keep an organization on the track, can make sure it has sound long range goals, can make sure that it is not arbitrary in its decisions. Such an advisory body inevitably must be critical, and criticism can be a painful spur to achievement.

I anticipate that the National Advisory Committee for Oceans and Atmosphere will be scrutinizing our philosophies, programs, and operations carefully over the coming years. NOAA can count itself fortunate to have the guiding hand of this distinguished group. We, and the country, will be the better for it.

During the month of December, the National Advisory Committee on Oceans and Atmosphere held its first meeting. This body, established at the request of the President by the Congress to undertake a continuing review of the progress of the marine and atmospheric science and service programs of the United States, and to advise the Secretary of Commerce with respect to carrying out the purposes of the National Oceanic and Atmospheric Administration, will have a formidable impact on the programs, policies, and methods of operation of our organization.

There are many advisory committees with which we presently work in the various areas of concern to NOAA—for example, the Sea Grant Program, our marine fisheries activities, our science and engineering activities; but only NACOA has a statutory basis and only NACOA is required by law to submit each year a comprehensive report to the President and to the Congress setting forth an overall assessment of the status of the nation's marine and atmospheric activities.

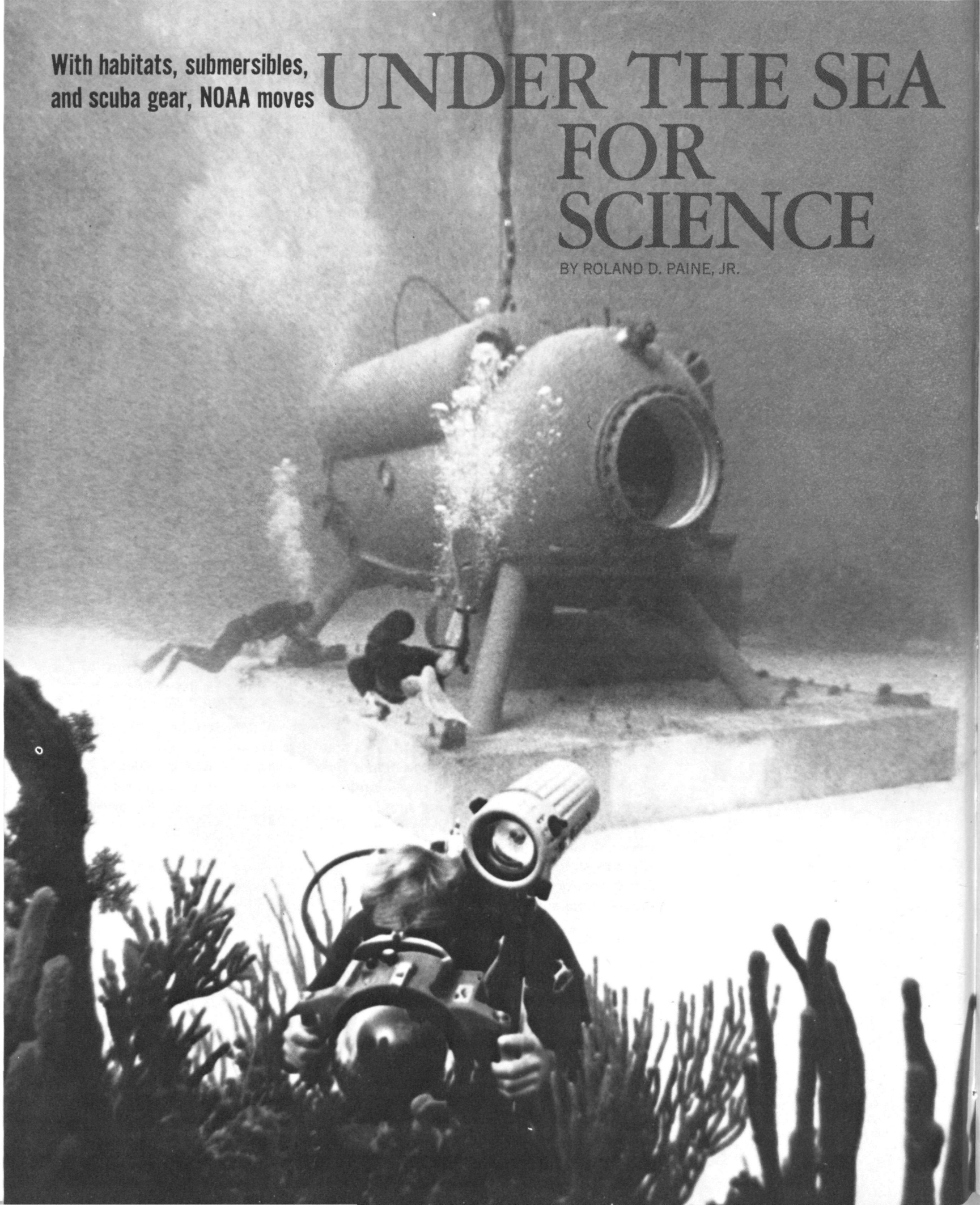
Chaired by Dr. William Nierenberg, Director of the Scripps Institution for Oceanography, NACOA is composed of a distinguished group of twenty-five members chosen from fields of science and engineering, industry and commerce, the general public and labor, public administration and political science, conservation, and state and local government. Never before have the marine and atmospheric activities of our Federal Government had such a means for obtaining the views and comments of representatives of all those in our society who are affected by or who are involved in one aspect or another of these fields. The committee is endowed with substantial legal authorities which will enable it to be effective.

Robert M. White

With habitats, submersibles, and scuba gear, NOAA moves

UNDER THE SEA FOR SCIENCE

BY ROLAND D. PAINE, JR.



A MARINE GEOLOGIST in a little yellow submarine, nosing around the Continental Shelf, uncovered data that has completely overturned a long-held theory about the shelf.

Two other marine geologists have inspected at first hand seafloor litter thrown from ships, and gained new insights into how it may be moved around by ocean bottom currents.

And scientist-divers doing research from an undersea laboratory have made important new discoveries about how fish behave toward different kinds and emplacements of traps.

In each case, scientists on the scene—deep down in the ocean in special research submersibles or habitats—have found useful and important information that could not have been obtained by indirect sensing methods from the surface. In each case, too, the underwater facilities were made available by NOAA's Manned Undersea Science and Technology (MUS&T) program, working closely with other NOAA components including the Sea Grant program, the National Marine Fisheries Service, and the Environmental Research Laboratories.

MUS&T is a national civilian undersea science and technology program, begun in August 1971 as part of NOAA's responsibility for significantly increasing our knowledge of the ocean's resources and processes. Impetus for its formation came from the recommendations of several federal marine councils, advisory panels, and the Commission on Marine Science, Engineering, and Resources. Its objective is to develop the nation's capability to work in all depths of the oceans and to promote research and development programs necessary for their effective use and management.

Gearing up for the program required a staff knowledgeable in the needs of the scientific community and experienced in undersea operations. First on board was Dr. James W. Miller, director of the Interior Department's Tektite II operation which took place in the Virgin Islands in 1970. In adition to tying up the remaining loose ends of that eight-month-long undersea habitat experiment, he began to pull together the plan for NOAA's program. Dr. Miller was soon joined by John VanDerwalker, a marine biologist and former Tektite II aquanaut.

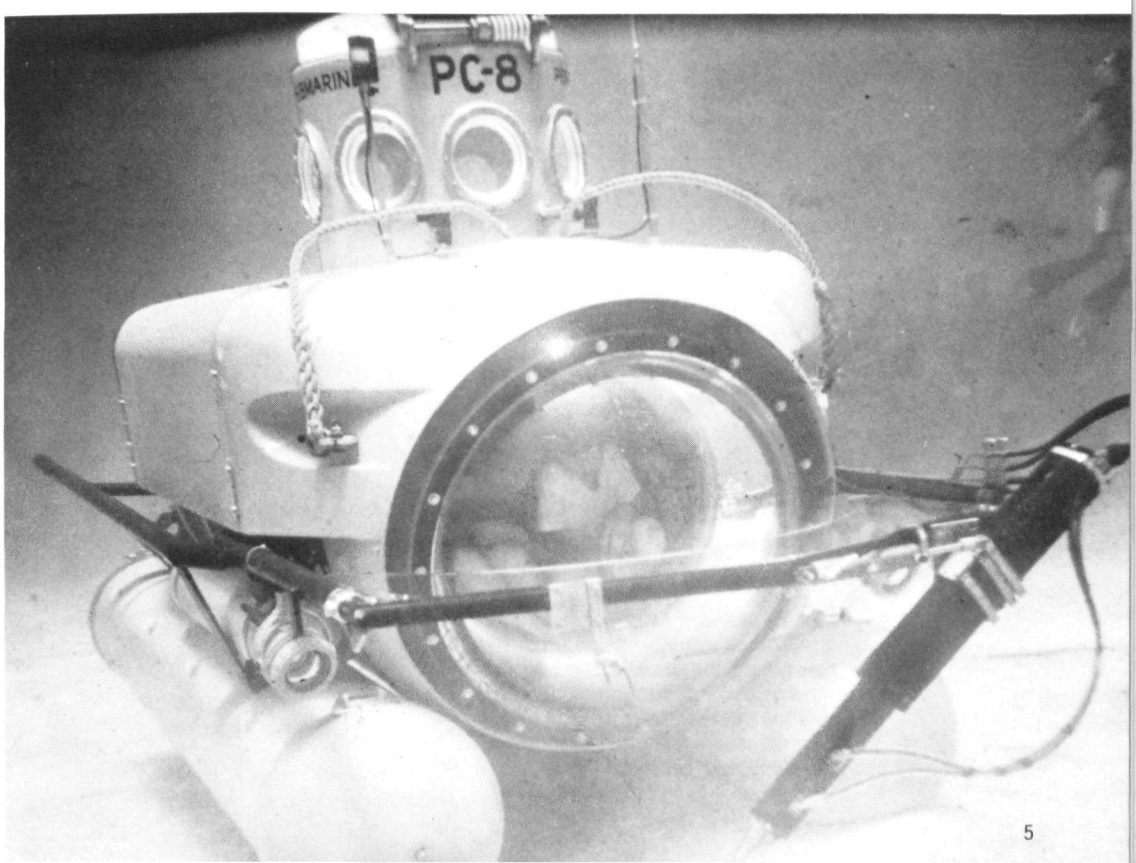
During this period, too, the first arrangements were made to use existing undersea facilities operated by private firms and by universities, so that productive scientific work could be undertaken as soon as possible.

A significant portion of the NOAA briefing to the Marine Technology Society on August 18 in Washington dealt with the plans of the newly formed program. Deputy Administrator Howard W. Pollock, himself an ardent scuba diver, spoke of the general philosophy underlying NOAA's plans for undersea work. Dr. John W. Townsend, Jr., Associate Administrator, made the first public announcement of the initiation of the program, and discussed some of the details of its planning.

The first scientists to make operational use of the new program were from the NMFS Boothbay Harbor Biological Laboratory at West Boothbay Harbor, Maine. The PC-8, a brand new two-man submersible with a transparent nose, was to be in the area and was available for lease from its owner, Perry Oceanographics, Inc. Taking advantage of the opportunity, a NOAA lease was quickly concluded. In September the fisheries biologists made a total of 33 dives in the Gulf of Maine, some as deep as 750 feet below the surface.

continued

This transparent-nosed submarine, the Perry PC-8, was used in NOAA marine geology studies off New York City and New Jersey, in the Bahama Bank project to examine coral reefs, and in the Gulf of Maine to study herring, lobster, and shrimp.



In NOAA's two-week Bahama Banks study, William High and Ian Ellis of the National Marine Fisheries Service spent six days in Hydro-Lab, swimming out in scuba gear to install traps and observe fish behavior. Minisubs and diver propulsion vehicles were used in a variety of other studies in the same project. The Perry Hydro-Lab is a permanent undersea installation located in 50 feet of water about one mile off Grand Bahama Island. It is a steel cylinder 16 feet long and eight feet in diameter with eight viewports, a four-foot "picture window," and an underside hatch for diver entry and egress.

The mission of this project, and of those that succeeded it, was two-fold. One, a part of the overall research program of the Boothbay Harbor facility, was scientific—to conduct studies of bottom-living organisms in relationship to various physical characteristics of the ocean bottom. The other, equally important, was technical—to evaluate the usefulness of a submersible such as PC-8 as a platform for fishery studies. For it is an integral part of the MUS&T program that the science and technology go hand in hand. Scientific and engineering projects that require underwater capabilities are to be supported as quickly as circumstances permit, while the development of improved techniques and improved facilities does not proceed in a vacuum, but always with an eye to what will be of optimum use to the scientific community.

And what did the scientists from the Boothbay Harbor laboratory discover, deep down in the cold Maine waters?

For one thing, lobsters. They observed large, commercial-sized lobsters in mud burrows at the bottom of two channels, in depths of 150 to 200 feet. All the lobsters were adult, and shedding in colder water than had been anticipated.

For another thing, no lobsters. In parts of the bottom where they had hoped to find many lobsters, they found none, nor did they find any burrows or other signs that lobsters had ever been there. They found only one lone lobster at a depth greater than 250 feet, even though the bottom was suitable for them. In a major shallow water bank, Stellwagen Bank, where they had thought they would find lobsters, again, they found none.

They also found no ill effects on a two-pound lobster that they caught in 750 feet of water and brought rapidly to the surface. Some fishermen had speculated that lobsters, like humans, would suffer from "bends" in such a case.

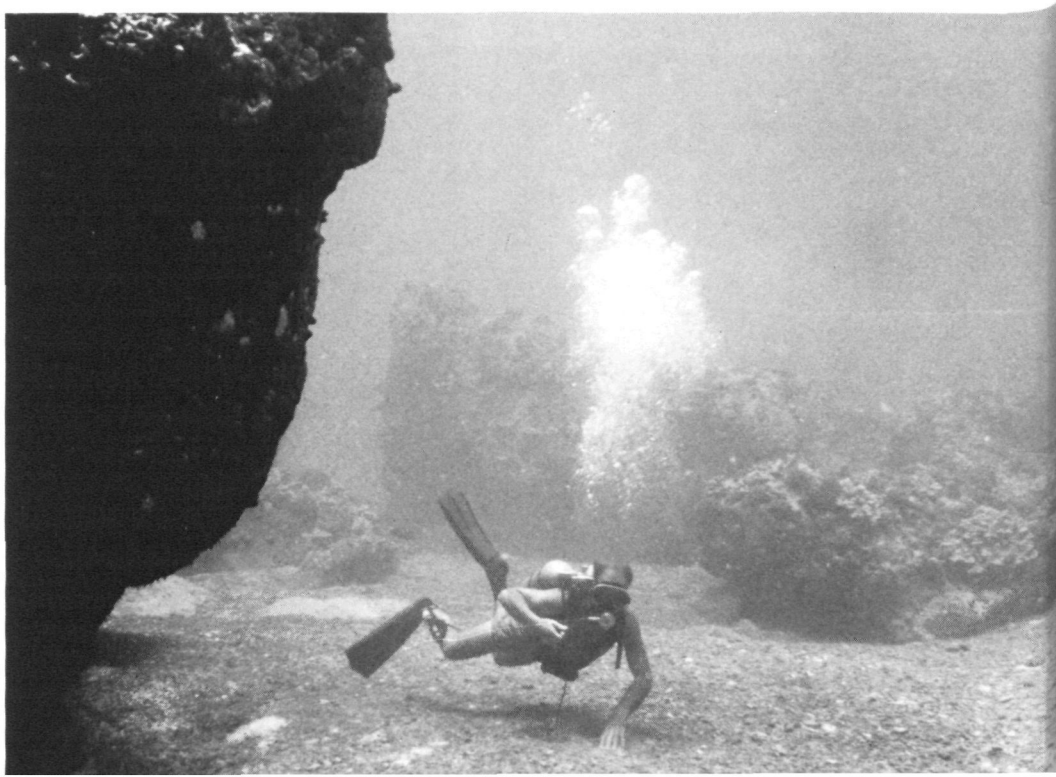
Other results reported by Dr. Richard A. Cooper and Joseph Uzmann, the program directors who led the expedition, were:

- There were no sharks in the area, so it is apparently safe for future saturation dives;
- Twenty-three commercial fish species were counted;
- Of the many shrimp that they saw, there were only males at 100-250 feet, and increasingly larger proportions of females at increasing depths (a fact that is probably related to this, though they don't yet know how, is that these shrimp are all males when they are first hatched; at about three years of age, they all metamorphose into females;)
- All the shrimp they saw had their heads down-current, and many seemed to spend their lives walking around on the mud bottom. This discovery may suggest that shrimp gear should be designed to be in constant contact with the bottom.
- Schools of adult herring actively avoided the lights on the submersible, suggesting that future on-site herring behavior studies will have to be conducted in ambient light from craft sitting on the bottom with searchlights off;
- Detailed biomass estimates on some 20 species of finfish and invertebrates were obtained.

Altogether, the project was highly successful, yielding many interesting and some totally unexpected results. To the scientists conducting the project, this knowledge could only have been gained through the use of a submersible such as the PC-8, and they are highly enthusiastic about the possibilities of future on-site underwater work.

Meanwhile, back at NOAA the programming, operational planning, and staffing proceeded steadily. The U.S. Navy made available to the program, as liaison officer from the Office of the Oceanographer, Cdr. Robert Nevin, formerly the commanding officer of the bathyscaphe TRIESTE. Also joining the program was Dr. Robert Dill, a marine geologist who had pioneered in the use of small submersibles and made many scientific dives with Jacques and Philippe Cousteau. Dr. Dill had investigated deeply submerged terraces on the Continental Shelf. One of his reports, made in the form of a technical film, won the Thirteenth Annual Industrial Film award.

It was appropriate, then, that the next operational project stemming from MUS&T was a marine geology study. Dr. Donald Swift of the Atlantic Oceanographic and Meteorological Laboratories was provided with the use of PC-8 for two weeks of work in the New York Bight—the stretch of Continental Shelf between Cape Cod and Cape May, N.J. The first dive, with Dr. David Duane of the Army Corps of Engineers, was to inspect the site where New York city dumps large volumes of waste material. Another dozen dives were made along the New Jersey coast, looking at the sandy ridges and swales (troughs) characteristic of the seafloor in places along the coast. His study is part of a major scientific effort by AOML and MUS&T to learn more about the relationships between the deep currents that flow along the top of the Continental Shelf, and the topography of the shelf itself.



NOAA's Manned Undersea Science and Technology program involves scuba diving from craft on the surface and from habitats on the seafloor. The habitats permit divers to stay down longer for studies of marine geology, marine biology, and other investigations.

The dive with Dr. Duane was impeded by sediments that were still stirred up from the effects of hurricane Ginger. But the dives along the New Jersey coast—made with several other NOAA personnel and with a graduate student assistant from Old Dominion University—turned up data of great scientific importance, as well as of possible practical application.

In sum, Dr. Swift found that storm currents move seafloor sediments about, causing slow but unmistakable changes on the shelf. The classical theory that nothing significant has happened to Continental Shelf topography since the end of the ice age, he concluded, is wrong.

The changeable currents of the ocean over a period of time constitute the "climate" of the Continental Shelf, he believes. These ocean currents act on the topography of the shelf in a manner analogous to the actions of the climate on the topography of the land. Currents during fair weaher—like the gentle zephyrs of land—have little effect on the underlying topography, but the powerful onrush of storm currents, like gales and hurricanes, make marked alterations on the form and shape of the earth below.

He discovered that the sandy ridges in depths of about 120 feet are up to 30 feet in height, with gently sloping sides. He found medium sand on the crests, fine sand on the slopes, and coarse sand in the troughs along this undulating surface. The substrate—older sediments, usually in the form of hard muddy sand—was frequently visible in the bottom of the troughs.

He concluded that the troughs are swept out during storms, which push masses of water down the coast with great force and regularity. During fair weather, gentle wave surges winnow the crests, pushing the fine sand down onto the slopes.

His findings are directly relevant to the problem of large-scale offshore waste disposal. While heretofore it had been assumed that waste material dumped well away from land would tend to stay in the area where it is dumped, his findings indicate that it might be carried for many miles under water, potentially affecting large areas of the sea bottom.

Again, the little submersible proved its worth to the scientists. They visually examined the seafloor with the aid of powerful searchlights, photographed the bottom, and took current velocity measurements and seafloor grab samples.

Dr. Swift plans to extend his study for several years, making two series of dives each year to learn more about the seasonality of sediment transport and to verify his initial findings.

During the planning period for this project, major management capability and additional scientific expertise were added to the MUS&T staff, with Dr. Donald C. Beaumariage coming on board from private industry as program director, and William H. Kumm, an interchange executive on the President's Commission on Personnel Interchange assigned to NOAA, and detailed to MUS&T. Dr. Kurt Stehling came from the National Council on Marine Resources, as science advisor.

The next field operation was another AOML marine geology study. The three-man submersible ALVIN and her catamaran mother ship LULU, operated by the Woods Hole Oceanographic Institution, were available for three weeks in the Florida Straits. Scientists from AOML, Woods Hole, and the Rosenstiel School of the University of Miami, explored several mysterious seafloor features, and the relationships between them and ocean bottom currents.

Led by Dr. George H. Keller and John W. Kofoed, the team made numerous dives to depths as great as 3600 feet south of the Dry Tortugas and the outer keys and along the Bahama Bank. In one six-hour dive, a half-mile-diameter hole in the ocean floor 20 miles south of Key West was explored. The scientists concluded that it is probably a sink hole caused by an undersea fresh water source that eroded away the limestone. The sink hole, whose lip is at the seafloor in 865 feet of water, is an additional 480 feet deeper.

The ocean bottom in this area, they reported, was littered with debris from many ships that have traversed the waters. They saw dishes, boots, iron bars, and a great deal of other material.

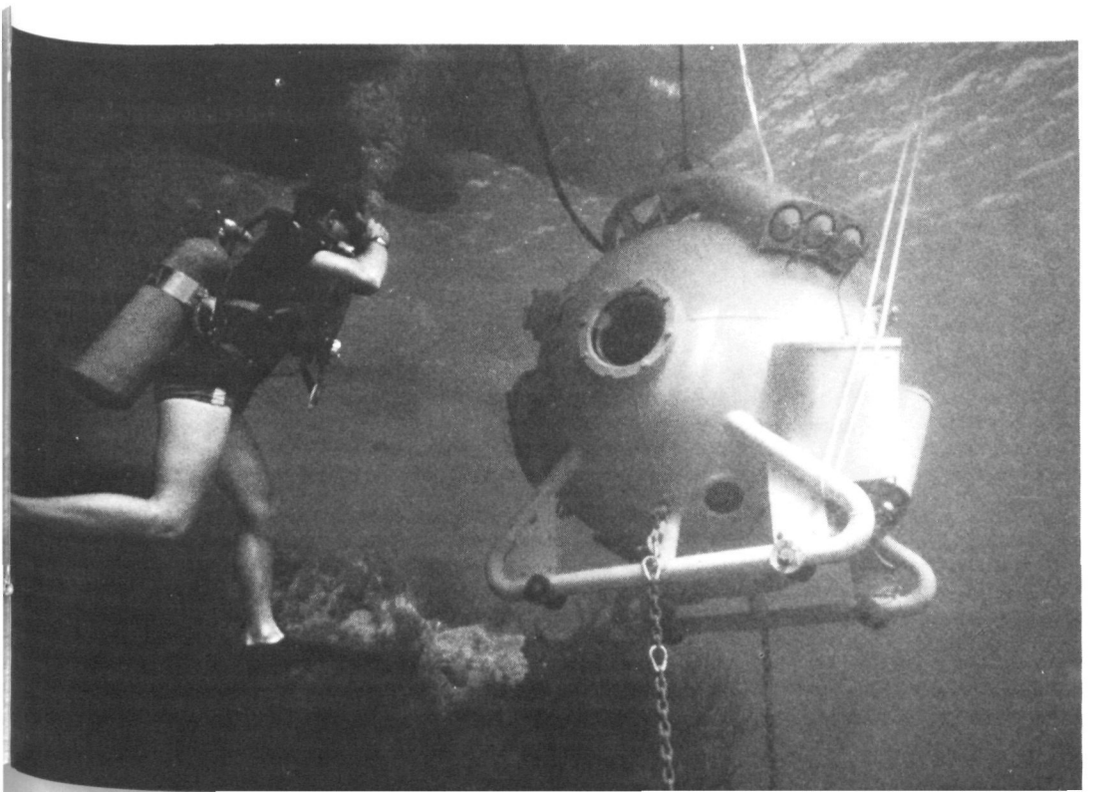
During these first three MUS&T-supported projects, concentrated planning was undertaken for two new projects that involve habitats or underwater laboratories, where divers can live, sleep, and work for periods of time. One, which took place in late November and early December, was a two-week study of the Bahama Banks, and made use of a habitat, minisubs, and diver propulsion vehicles in support of a variety of research projects.

The other, which begins this month and will continue through late April, is Project FLARE, the Florida Aquanaut Research Expedition, which will be NOAA's largest undersea operation to date.

Scientific projects undertaken in the Bahama Banks study included:

• Characteristics of fish behavior that can be used to increase fish trap efficiency, by William L. High and Ian E. Ellis of the North Pacific Fisheries Research Center;

continued



In some undersea projects, a personnel transfer capsule is used to transfer divers under saturation to a ship. Divers enter the capsule deep under the water and are hoisted aboard ship, where they immediately enter a deck decompression chamber to avoid the "bends."

• Differences between day and night distribution of plankton (the base of the food chain) along the coral reefs, by Sea Grant scientist Dr. William W. Schroeder of Texas A & M University;

• Fluctuations of the sea level during the last ice age, by Dr. Dill of MUS&T (continuing work that he had undertaken with the Cousteaus), Dr. Beaumariage of MUS&T, and Dr. Robert Dietz of AOML.

Messrs. High and Ellis continued work begun by High as a Tektite aquanaut. They carried out a six-day research mission from Perry Hydro-Lab, a permanent undersea installation located in 50 feet of water, about one mile off Lucayan Beach, Freeport, Grand Bahama Island. Hydro-Lab is a steel cylinder 16 feet long and eight feet in diameter with eight viewports, a four-foot "picture window," and an underside hatch for diver entry and egress.

Living in this chamber, and swimming out in scuba gear to install various types of traps and observe fish behavior, High and Ellis gained clues about the placement of traps with respect to coral reefs, and the possibilities of divers working underwater with fish trap equipment—information that they hope will help lead to increases in fishery yields.

Their experiments did not upset the natural ecosystem and all fish were released unharmed from their traps.

While they were living and working around Hydro-Lab, Dr. Schroeder was diving nearby using underwater propulsion units to move him with relative ease and great accuracy of location at various depths. Conventional plankton-sampling methods involve towing nets from surface vessels, and do not permit scientists to know exactly where, or at what depth, the specimens were collected. Dr. Schroeder located his nets on the front of a little "underwater sled," and made precise collections, both day and night.

Dr. Dill, Dr. Beaumariage, and Dr. Dietz made several dives in PC-8 and ALVIN, looking into the history and physical characteristics of the coral reefs in the area. Dr. Dill had learned from his previous dives in waters around South America, Australia, and Baja California that there is consistent evidence of oceanic flooding in a series of steps, since the end of the ice age. These steps, or deeply submerged terraces, he found, exist at depths of about 40 feet, 60 feet, 90 feet, 125 feet, 150 feet and 180 feet. They appear to be old beaches ("stillstands"), formed when the waters stayed relatively level for long periods of time, then drowned when the waters once again advanced. In the Bahama Bank dives, he found still deeper terraces, at about 600 feet, thereby making possible a worldwide correlation of his observations and showing the youthful nature of these features.

These terraces cannot be found by conventional indirect sounding methods from the surface, and their existence was not known until deep-diving submersibles became available for research.

The turn of the year found NOAA's Manned Undersea Science and Technology program only five months old, with a record of four successful projects involving a great variety of facilities and equipment, several highly significant research findings, and close cooperation with private industry and academic institutions. It also found the program right on the verge of the operational phase of its most diversified project to date, Project FLARE.

FLARE began almost before MUS&T did. In fact, when FLARE first began to be discussed, MUS&T had not yet been formally organized. Since Sea Grant institutions would be heavily involved, the Office of Sea Grant offered to help out, and early FLARE plans were put together by Harold Goodwin, Deputy Director of that Office. The project management and much of the funding was assumed by MUS&T when it was activated, with Sea Grant continuing its close cooperation and partial funding.

The roots of FLARE lay in a joint project by the University of New Hampshire and Woods Hole Oceanographic Institution more than a year ago, near the Isle of Shoals off the New Hampshire coast. New Hampshire's new habitat EDALHAB, built with the aid of Sea Grant funds, combined with the WHOI support ship LULU in a project to see if Pacific Dungeness crabs could co-exist with lobsters.

Looking at the LULU-EDALHAB combination, scientists with interests in undersea work began to realize that all previous United States habitat operations had been undertaken with fixed, immobile habitats. It was now time to explore the possibilities inherent in a movable habitat—one that could be emplaced for a period of time to accommodate one or more scientific projects, then moved to another location with relative ease, there to serve as temporary underwater home for other projects.

In addition, both LULU and EDALHAB were to be available in the early spring of 1972. And there existed a large backlog of scientific and engineering work, some stimulated by Tektite, that could make good use of an underwater facility of this kind.

Out of this ferment of ideas and facts arose FLARE. It encompasses a variety of scientific projects, both biological and physical. It also encompasses the mobile-habitat concept, as a further step forward in undersea technology development. In fact, FLARE is designed to stress the system, to test it fully with available facilities, so that the greatest number of lessons can be learned for design of future mobile-habitat operations.

Additional technological objectives of FLARE include testing the effectiveness of habitat subsystems including motion damping and safety devices, testing diver physiology telemetry systems and voice communication systems, and applying short- and long-range sea-state and weather forecasts to an operational system. The National Weather Service is cooperating closely in the last-named work.

In all, up to eight scientific missions will be undertaken, with change of location between missions as scientific objectives may require. Location change is also planned during one project, which requires four to five sites with 48 hours each—provided weather and sea-state conditions make this possible. Many scientists both from NOAA and from the academic world will take part.

A study of the effectiveness of manmade reefs in attracting fish will be made by Harold L. Pratt and Richard B. Stone of the National Marine Fisheries Service. About 100 automobile tires were emplaced several months ago to make up the reef. Messrs. Pratt and Stone will observe the fish population of the artificial reef, with a view to learning about the possibility of improving or rehabiltating reef-barren areas of the ocean bottom to increase fish yields.

Messrs. High and Ellis of NMFS, who undertook the Hydro-Lab fish behavior studies, will continue this work from EDALHAB. Dr. Sylvia Earle and Carol Aregood of the Los Angeles Museum of Natural History, who were Tektite "aquanettes," will continue their study of the interactions of marine plants and herbivorous animals on the coral reefs. They are gathering basic data on the feeding habits of plant-eating fish, and trying to assess their influence on the reef vegetation.

A man-and-wife team consisting of Dr. Morgan Wells of the University of North Carolina and oceanographer Anna Wells of the North Carolina public school system will make comparisons between two coral reefs, one undisturbed and one that has been subjected to heat or sewage pollution. They will compare the metabolism of the two reefs, measure the daily cycles of photosynthesis and respiration, and evaluate the results of man-induced changes on the reefs.

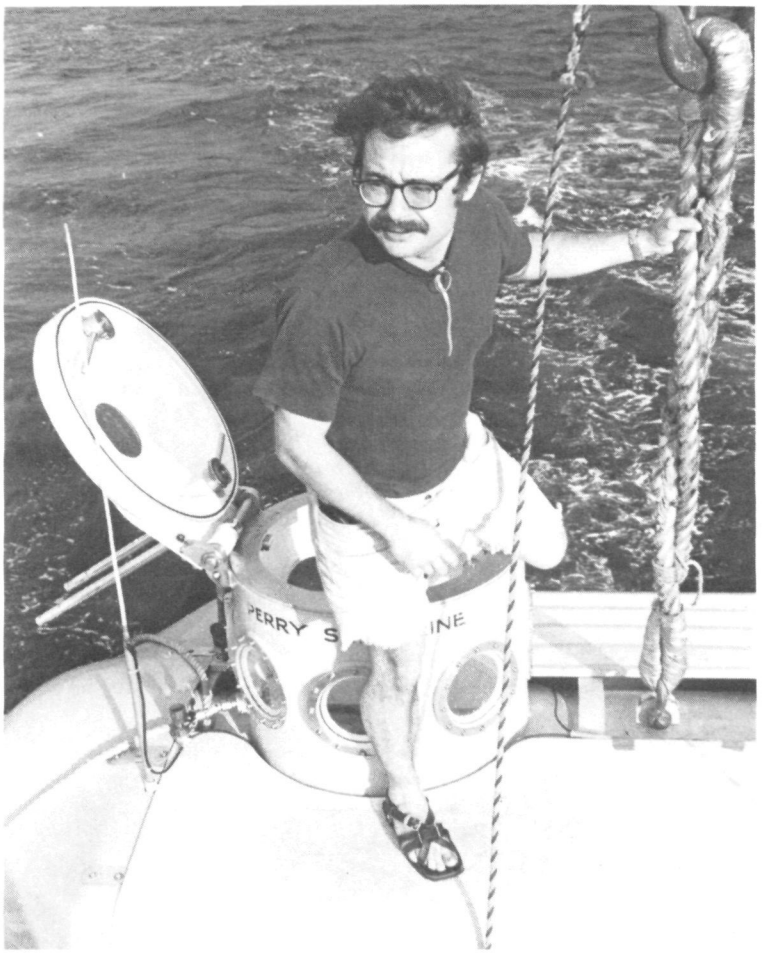
The primary food production system of the coral reefs, seaweed, will be studied by a botanical team from the University of New Hampshire, led by Dr. Arthur C. Mathieson. Their study is related to that of Dr. Earle, and will also incorporate information of the feeding habits of fish.

The fish themselves will be studied by Dr. C. Lavett Smith of the American Museum of Natural History and Dr. James C.

continued

The three-man submersible ALVIN aboard the catamaran mother ship LULU. Both are operated by the Woods Hole Oceanographic Institution. In the Florida Aquanaut Research Expedition, LULU will serve as the support ship for EDALHAB, the University of New Hampshire's new movable habitat, which can be emplaced for a period of time for one or more scientific projects, and then moved to another location with relative ease.

The submersible ALVIN was used in a three-week NOAA undersea project in the Florida Straits, when scientists from the Atlantic Oceanographic and Meteorological Laboratories, Woods Hole, and the Rosenstiel School of the University of Miami explored seafloor features and their relationships to ocean bottom currents. ALVIN also participated in the November-December Bahama Banks study.



Dr. Donald Swift of the Atlantic Oceanographic and Meteorological Laboratories emerges from the PC-8 after a dive off the New Jersey coast to look at sandy ridges and swales on the seafloor.

Dr. Sylvia Earle, who will lead a two-woman aquanaut team in NOAA's FLARE project, headed an all-woman team in the TEKTITE II experiment.

Tyler of the Academy of Natural Sciences, Philadelphia. They plan to take a census of fish in a small patch reef or coral stack, and observe their hunting areas, activity cycles, and behavior patterns when nesting or defending territories.

Two projects from the Rosenstiel School of Marine and Atmospheric Sciences of the University of Miami will look at the chemistry and geology of the coral reefs. Dr. E. F. Corcoran is seeking a basic understanding of the composition and environment of a reef, with daily rhythms recorded to gain a fuller understanding of the influence of reefs on the marine life. Dr. Cesare Emiliani will lead a geology team that will "vacuum clean" a small area of seabottom and drill into the bedrock floor. The geologists are trying to piece together information about the earth's ice age history, as recorded in the reef topography and geology.

Among the important support personnel that have been brought together by MUS&T and Sea Grant for this project will be Tom Mount, diving supervisor for the Rosenstiel School and Miami's Sea Grant Program, and Dr. William Hulet and Dr. Ron Samson, medical personnel from Miami. Mr. VanDerwalker of MUS&T is coordinator, and William Rainnie of Woods Hole is expedition leader.

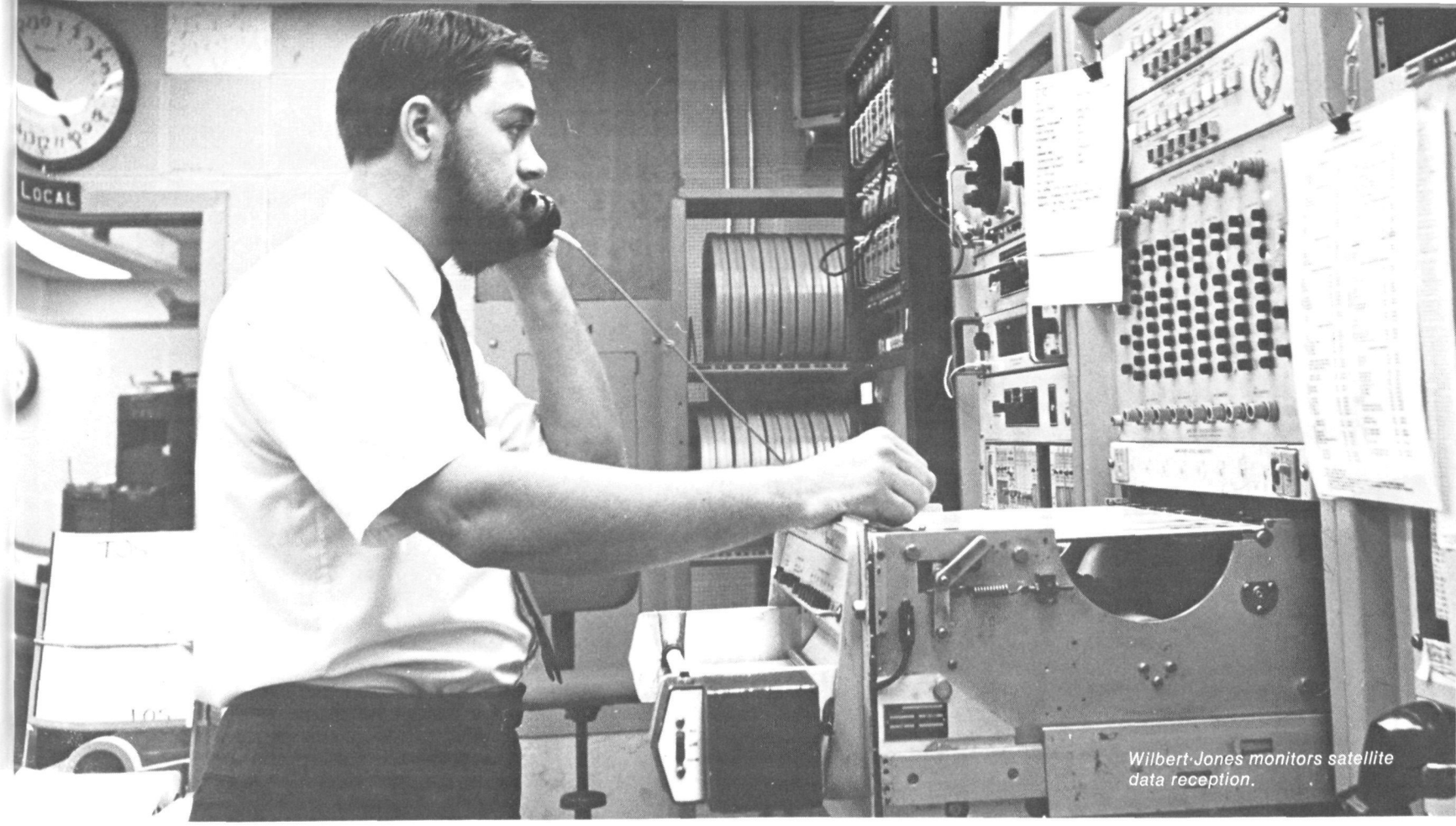
While the operations are going on in the tropical Florida waters, plans for additional projects are being drawn up at NOAA. As outlined in the briefings at the Marine Technology Society, the west coast will be included in future operations, in conjunction with the Navy. Among the topics being considered are effectiveness of deep-water fish traps, submarine high velocity currents, submarine bioerosion, solid-waste dispersal, and activity of offshore faults. It is hoped that submersible surveys can be undertaken preparatory to placing an underwater laboratory in the California Borderlands.

A careful effort to define long-term needs and develop a continuing program responsive to national needs is being made concurrently with the initial operational phases. The advice of the scientific community is being actively solicited, and will be incorporated in a continuing way in the formulation and elaboration of the program.

Among the projects under consideration is drawing up a comprehensive diving manual for civilian purposes. The U.S. Navy diving manual has long been the world's standard, and is designed essentially for men under military discipline performing work of a military nature. A whole host of scientific needs that do not conform to the military pattern must also be answered. Two noteworthy attempts to meet these needs for the research diving community have been the diving manuals published by Texas A&M University and the University of Michigan under their Sea Grant programs. These will be invaluable—and in some respects they are paving the way—for the proposed NOAA diving manual.

What else is in the future? Scientific and technological needs, engineering feasibility, and funding availability hold the keys. But among the MUS&T staff and their colleagues throughout the world of undersea research, many tantalizing ideas are being discussed . . . a semi-mobile bottom-sitting undersea laboratory with self-contained power source . . . a fully autonomous mobile support laboratory to support submersibles, unmanned vehicles, bottom sensor pods, and surface buoys . . . under-ice or in-ice navigational systems . . . a whole range of submersibles, habitats, undersea laboratories, and diver propulsion units available to meet all the significant research and development needs that might arise . . . undersea ports . . . seafloor work stations . . . voyages of scientific exploration to look for marine minerals and geothermal energy sources.

For the first time, the United States has a continuing national program to explore, utilize, and conserve the underwater environment As the program continues, the nation may expect many of these tantalizing ideas to become reality. □



Wilbert Jones monitors satellite data reception.

NOAA SPACE COMMAND

BY ANN K. COOK

A unique NESS facility controls operational satellites and treats their ailments.

"Gilmore, this is SOCC. Are you ready for pre-pass check?"

A member of the team on duty at SOCC—the Satellite Operations Control Center in the National Environmental Satellite Service at Suitland, Md.—was speaking through a voice communications system to the Command and Data Acquisition station at Gilmore Creek, Alaska.

NOAA-1, traveling at 16,000 miles per hour, would soon be coming over the horizon into acquisition range of the station at Gilmore Creek. The satellite held stored pictures of global weather systems taken in daylight and darkness by vidicon cameras and infrared sensors, ready to be transmitted on command from the ground.

The command messages to be given to the spacecraft had been sent in advance by teletypewriter from the Control Center to the CDA station and now were being double-checked.

Gilmore responded loud and clear: "Sequence Alarm 1 at 2025:00Z commands 4200 2002 0012. Sequence Alarm 2 at 2026:00Z commands 6000 0120 7012. Sequence Alarm 3 at 2035:00Z commands 2702 0012."

In the message, the first number in each sequence indicated the Greenwich time when the command was to be given to the spacecraft. The next number in Sequence Alarm 1 was the command "4200," which set a pre-established picture-taking schedule for subsequent orbits; command "2002" told the satellite to turn on its transmitter; and command "0012" instructed it to transmit information on the state of its subsystems—what is termed "housekeeping" data.

In Sequence Alarm 2, the command "6000" would activate the recorder to play back stored scanning radiometer data; "0120" meant turn on the vidicon camera's tape recorder for playback; and "7012" called for another readout of housekeeping data.

In the third sequence, "2702" said turn off the transmitter, and "0012" asked for another report on the state of subsystems. Such repeated calls for housekeeping information give satellite controllers a look at how the readout operations affect the condition of the spacecraft.

As the commands were sent to the spacecraft, they were monitored jointly by the Command and Data Acquisition station and by the Control Center.

Altogether, some one hundred possible commands—programmed into the satellite before launch—can be given. Transmitted from a CDA station, the signals are received by the satellite's command decoder, which routes them to the appropriate subsystem.

When the satellite is asked for the vidicon camera data taken on the last revolution, 11 pictures are played back from the spacecraft tape recorder, the signals being received at the Command and Data Acquisition station in 2½ minutes. Transmission to Suitland is slower; all picture signals will have arrived there just over 20 minutes later.

In an average 24-hour period in the Control Center, such exchanges take place thirty-five or more times, as the staff monitors operating spacecraft and their onboard systems, transmits commands, and acquires data.

Under the leadership of Alphonso Butera, the Control Center was established when the operational satellite system began in early 1966. The only facility of its kind staffed by Civil Service personnel, it has evolved through three spacecraft systems—the polar-orbiting ESSA and NOAA, and the earth-synchronous ATS series—and is now preparing to handle more elaborate spacecraft systems.

continued

Spacecraft in polar orbit obtain environmental data along the track beneath the satellite and either transmit the data directly to receivers throughout the world, or record it for playback at a later time to the NOAA Command and Data Acquisition stations.

The two earth-synchronous Applications Technology Satellites—ATS-3 over the Atlantic, ATS-1 over the Pacific—remain over the same area of the earth at the Equator, at an altitude of 22,300 miles, and acquire picture data when the hemisphere is illuminated by the sun. These spacecraft are also used to transmit picture mosaics and other facsimile weather data to receivers within range of the satellites.

Although the two ATS's are National Aeronautics and Space Administration spacecraft, the Control Center assumes command responsibility for picture acquisition and for facsimile transmissions during certain assigned periods. In the tornado and hurricane seasons, pictures from ATS-3, whose view includes the United States, are gathered for about eight hours a day—longer if severe weather is expected.

The large main room of the Center—hub of the operational satellite system—is set behind a glass wall, so that visitors can observe without disturbing vital operations. The control room is manned around the clock by teams of four men, working in shifts.

Here, command programs are written for the spacecraft and incoming data is monitored. Here, too, the satellite orientation and the "health" of the satellites' systems are watched through telemetry from the spacecraft. On the basis of this information, decisions are made for programming corrections in the spacecraft's orientation, determining when satellite spin rates must be increased to maintain stability in orbit, and whether subsystem operation needs to be altered.

The electronic arms of the Satellite Operations Control Center are the two Command and Data Acquisition stations at Gilmore Creek, Alaska, and Wallops Station, Virginia. The command programs originated in the Control Center are transmitted to the spacecraft by command antennae at the CDA stations. The CDA station's 85-foot parabolic antennae also receive environmental and telemetry data.

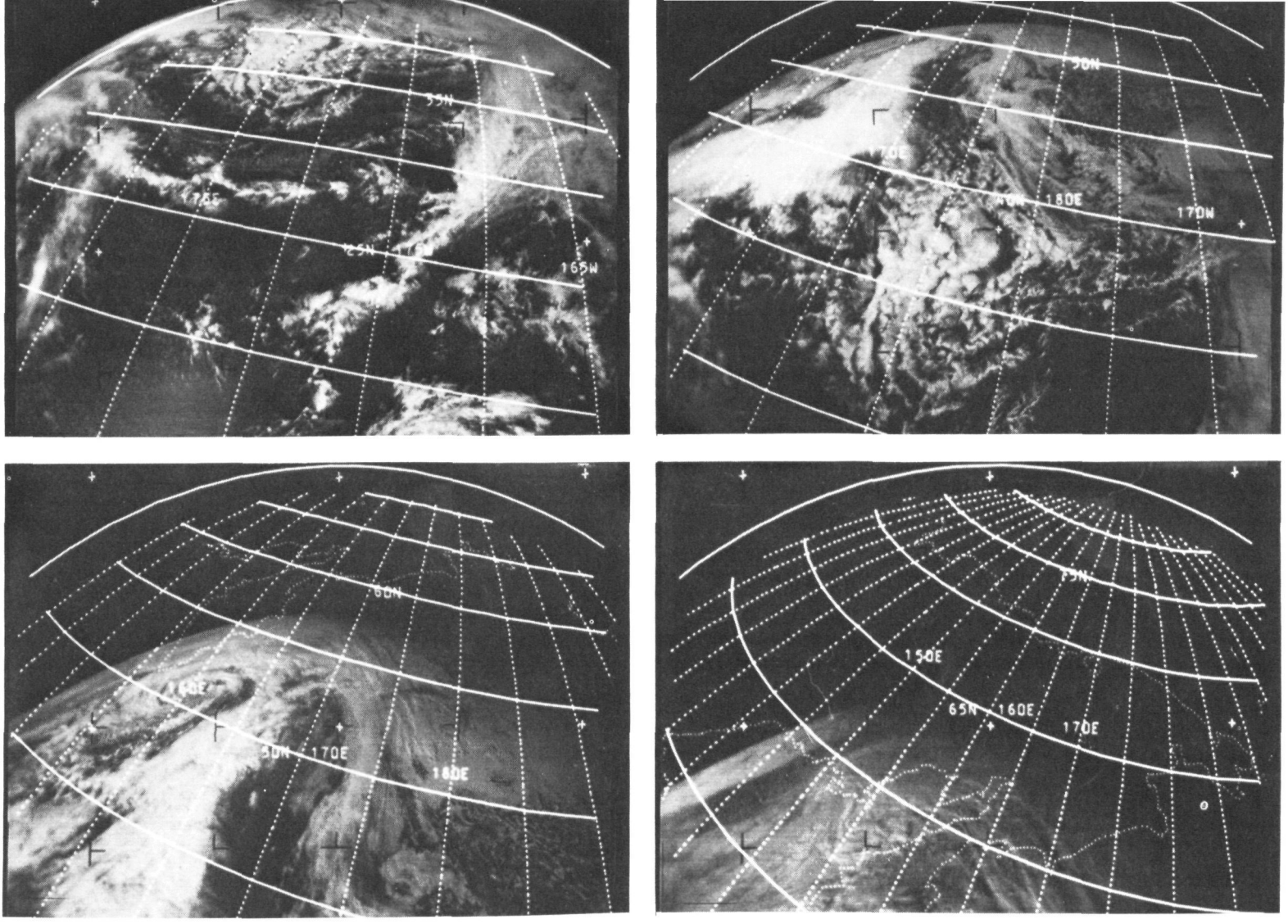
The Satellite Operations Control Center schedules the satellites for data collection to serve routine operational and special requirements. Operational users are principally the National Weather Service, the Department of Defense, and NOAA's Space Environment Forecast Center, the latter making operational use of solar proton data. Special uses include a variety of projects and studies and non-routine operational needs—such as the Navy's recurring requirement for pictures of weather systems in the Antarctic area during seasonal resupply missions.

Schedules for data acquisition are prepared a week ahead of time and sent to the CDA stations. Acquisition times for both stations are calculated by computer, based on the orbital elements of each satellite. Frequently, the computer printouts reveal a conflict—more than one satellite will be in receiving range of the same CDA station at the same time. The SOCC staff must make a choice of what data will be received from each spacecraft and when.

The CDA stations relay the Center's instructions to the satellite. One such command tells the satellite where and when (latitude and time) to start taking vidicon camera pictures on each revolution. Picture-taking latitudes must be changed as the sun's illumination of the earth beneath the satellite changes with the seasons.

By command to the spacecraft, telemetry data is transmitted to the CDA station and relayed to SOCC where it is plotted on graphs to learn, for example, whether the spacecraft's body temperature is rising, falling, or steady. If a subsystem appears to be failing, the SOCC team may turn it off and switch to its twin aboard the satellite. Most equipment in the spacecraft comes in pairs to provide longer lifetime. The team then will plan a series of tests to diagnose the subsystem's problem and, if possible, to cure it. So, the staff members must understand the workings of the spacecraft in minute detail.

(Below) Howard Turney at the ATS console checks picture quality. (Right) Elwyn E. Wilson, shift supervisor, takes one of the many calls from Command and Data Acquisition stations and operational users of the satellite data.



The "moon lock." In October 1966, ESSA 3 transmitted a picture sequence in which the first photograph was correctly oriented and succeeding ones turned farther and farther from the horizon.

Each of the four teams at the Control Center includes a shift supervisor, a technical supervisor, and two technicians. The technical supervisor, usually a professional in aerospace technology, writes the command programs for the spacecraft and must be an expert on the workings of the spacecraft in order to solve problems as soon as they appear.

On a recent morning, Elwyn E. Wilson headed the team on duty, with Wilbert Jones as technical supervisor, and Howard Turney manning the ATS console. The fourth team member was in training for operation of the forthcoming synchronous satellite system. Wilson, a former navigator and Air Weather Service officer in the Air Force, is a relatively new member of the staff, having been with the Center for 15 months. Howard Turney joined SOCC two years ago, after service in the Army Signal Corps.

Jones, on the other hand, has been with the National Environmental Satellite Service for seven years and was one of the original members of the SOCC team. Technical knowledge, he points out, is only a part of the job's requirements; the ability to make decisions quickly is just as important. "We have 15 minutes at the most to make changes if a 'glitch' occurs," he says.

Spacecraft malfunctions are the nemesis of the data-acquisition team. They may be of short or long duration, serious or not.

At such a time, a remarkably matter-of-fact voice from Gilmore was heard in the Control Center: "SOCC, S-band is fading. The pitch index pulse appears to be moving through, and the wheel speed has changed.

"Roger, Gilmore," SOCC responded. "It appears that the spacecraft is tumbling. Will you hold Sequence 2 please, until we verify that it locks on again?"

And two minutes later: "Gilmore, it appears that the spacecraft has locked on again. How is the S-band?"

From Gilmore: "S-band is 5 by 5 now. Shall I proceed with Sequence 2?"

"Roger, Gilmore, set Sequence 2."

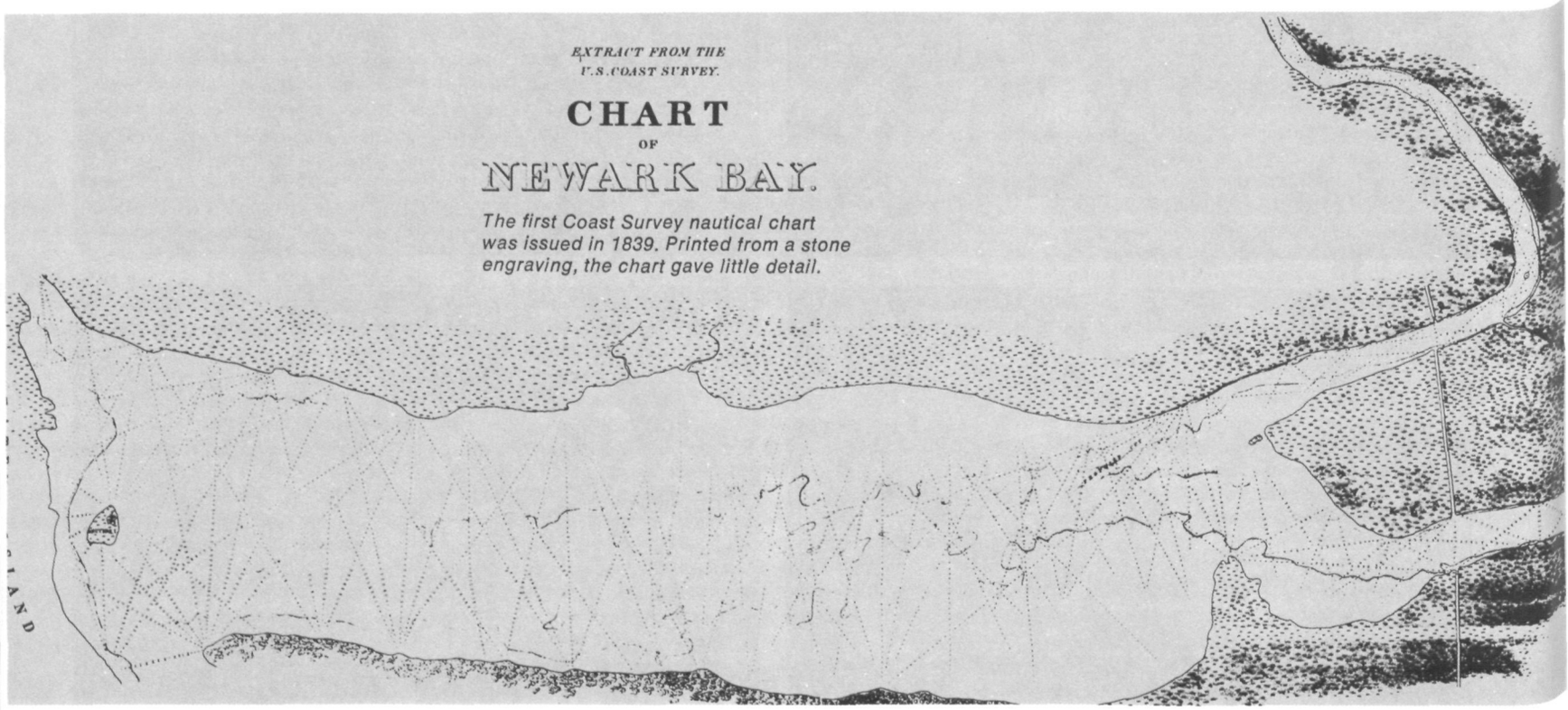
With the pass completed and the data acquired, the Control Center sought the reason for the spacecraft's tumbling. The supervisor and engineering staff analyzed the data to determine the cause. This analysis required examination of the telemetry with its information on electrical and thermal parameters, examination of the picture data, and calculations of space obstacles, such as the moon or sun, that may cause the control sensors to react.

Early in the operational system, the Control Center met and conquered an unanticipated problem. ESSA 3, launched in October 1966, transmitted a picture sequence in which the first photograph was correctly oriented and succeeding ones turned farther and farther from the earth's horizon out into space, ultimately photographing the sun.

What was wrong? The men of SOCC came up with the solution. The hatbox-shaped ESSA series of satellites wheel along in orbit, photographing only when the cameras point toward the earth. The earth-oriented picture-taking depends on a horizon-crossing indicator, triggered when it senses the earth's heat. But about once a month, the satellite and the moon are in the same plane and the horizon-crossing indicator "sees" the moon. If the moon is warm enough, and this depends on the moon's phase, the horizon-crossing indicator "locks" onto the moon. It then counts moon contacts as earth horizon crossings, causing the cameras to photograph too often. This space sleuthing by the Control Center produced a new series of commands, given to all ESSA spacecraft, to ignore the moon.

What the controllers call the "moon lock" has been corrected in the ITOS and NOAA series. These spacecraft have two horizon sensors at different angles, and the Control Center tells each satellite in advance which sensor to use to avoid lunar interference. Beginning with NOAA-2, new spacecraft will use carbon dioxide sensors to locate the earth, eliminating the moon conflict altogether. □

Since the first half of the 19th century charts issued by NOS and its predecessors have contributed to transportation safety.



The first Coast Survey nautical chart was issued in 1839. Printed from a stone engraving, the chart gave little detail.

CHARTMAKER TO THE NATION

BY RAYMOND WILCOVE

Back in 1839, when the United States consisted of 26 states and had a population of less than 17 million, the federal government issued its first navigational chart. Since then, the production of navigational charts, both nautical and aeronautical, has kept pace with the rapid expansion of the country.

Today, the National Oceanic and Atmospheric Administration issues approximately 43 million copies of navigational charts each year, a far cry from the 169 published in 1844, five years after the first chart was printed.

From the time the first nautical chart was produced in 1839 until the end of 1971, NOAA's National Ocean Survey and its predecessor, the Coast and Geodetic Survey, have issued approximately 875 million nautical and aeronautical charts and related publications, such as Coast Pilots, tide tables, tidal current tables, and aeronautical chart supplements.

At the beginning of the 19th century, when serious consideration was being given to the production of navigational charts, the nation consisted of 16 states and some interior territory. Land transportation was difficult because of the notoriously poor roads that existed then. Consequently, commerce between the states was largely by coastal shipping. Foreign trade, essential for the life of the country, was entirely by sea.

Due in great part to the lack of adequate nautical charts, shipwrecks were common. The coasts of the new country were lined with the wrecks of ships which fell afoul of uncharted reefs and currents. This resulted in high costs for products, steep insurance rates, and conditions generally unfavorable to commerce and industry.

The maps and other mariner guides then in existence were usually poor, spotty, and unconnected. Vague charts of sections of the coast had been made by the British government during the colonial period. The *Atlantic Neptune* contained a collection of charts prepared for the British fleet during the American Revolution. In 1730, Captain Southact of Massachusetts prepared the *Coasting Pilot*, comprising eight maps covering the coast from New York northward. These were inadequate for navigation but, along with other similar works, remained in use because there was nothing better.

The *English Pilot* of 1774 and 1794 contained material from scores of mariners, but fell far short of filling the needs of shipping. Some harbors had been poorly mapped by individuals or private companies. In 1796, the Blunt Company published the famous *American Coast Pilot*, or *Blunt's Coast Pilot*. This volume of written text and a few maps was a compilation of available material, including British work, private reports, and sounding and observations of seamen. Though a remarkable collection, it did not eliminate the hazards of navigation.

That charting should be a government responsibility had been

recognized for some time by scientific men, including members of the American Philosophical Society, founded by Benjamin Franklin. Thomas Jefferson and others proposed government action as early as 1800 and were later joined by commercial interests.

The first real coastal surveys made by the United States government covered North Carolina and portions of Louisiana, recently purchased from France. But these surveys, ordered in 1806, did not provide an overall survey of the coasts. They did, however, prepare the way for the enactment the following year of legislation providing for a "Survey of the Coast" for which an appropriation of $50,000 was authorized.

Congress thought the hydrographic survey it had authorized of the coast would encompass only a few thousand miles. From this humble beginning grew the vast undertaking of the new agency, which subsequently became the Coast and Geodetic Survey and, in 1970, the National Ocean Survey. Its task: to chart hundreds of thousands of miles of coastline at home and overseas.

Despite the urgent need for nautical charts (there obviously was no need then for aeronautical charts), progress was distressingly slow. Funds for the new agency were not provided until 1811, four years after Congress had created it. The man chosen for the job, Ferdinand R. Hassler, a Swiss engineer, had to develop a survey organization from scratch. Special preparations were required for the enormous task, including the procurement of instruments and equipment, even chart paper, since these were not available in this country. Hassler went to Britain and France for them in 1811. He did not return until 1815, for war with Britain intervened. During this period, he spent his time supervising construction and testing and standardizing the instruments built in accordance with his designs.

Hassler fully realized the magnitude of the job he was about to undertake because surveying at that time was much more difficult than it is today. His plan required the execution of a system of triangulation along the coast by which all subsequent detailed surveying operations could be accurately controlled, with each separate unit fitting exactly into the overall scheme. The control surveys of this country were thus begun, and since that time all topographic and hydrographic work underaken by the Coast and Geodetic Survey, and now the National Ocean Survey, has been rigidly controlled by triangulation.

The first maps were produced in 1834, showing the triangulation scheme in the vicinity of New York, Long Island, and the Connecticut shore, but hydrographic details of the offshore areas were not included. These were to come later.

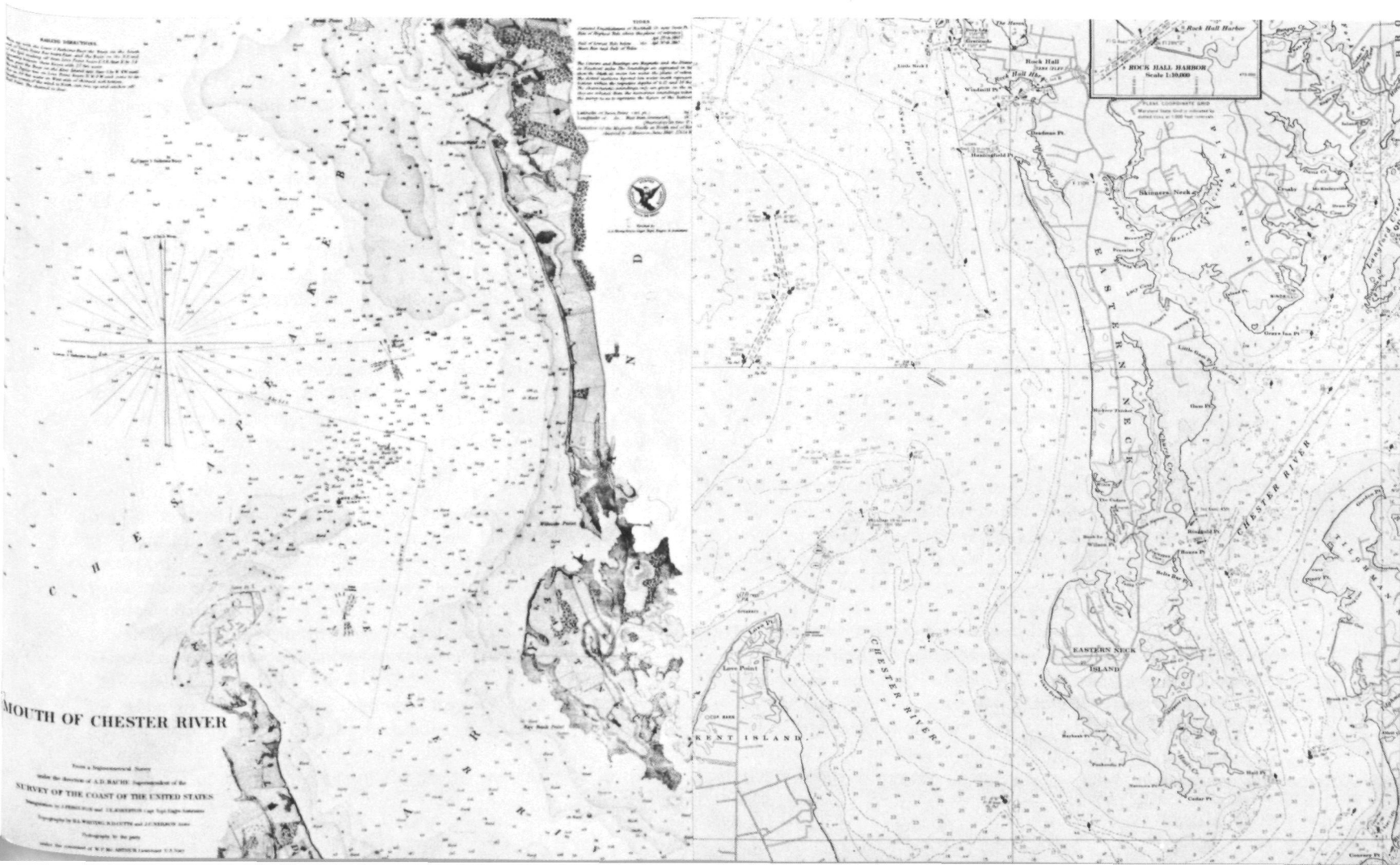
The first hydrographic survey was conducted in 1835 by the schooner EXPERIMENT under the command of Lt. Thomas R. Gedney on the Great South Bay and along the south shore of Long Island.

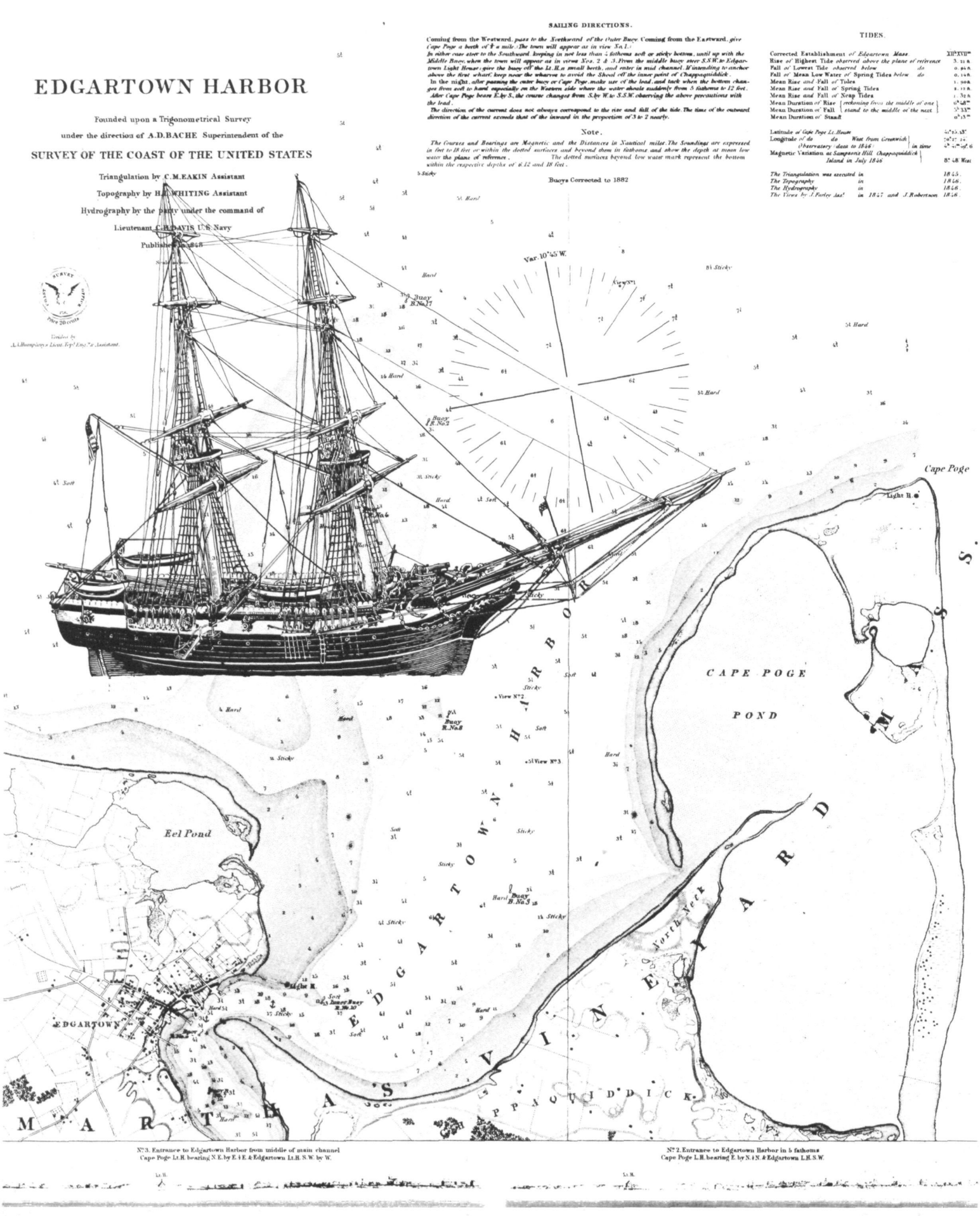
The earliest nautical chart, showing Newark Bay, was made from a stone engraving in 1839, but it gave little detail. By 1842, a copperplate printing press was obtained, and a chart of New York Bay and Harbor was issued in 1844. It was the first to be printed with the finer definition possible from a copperplate engraving. The earliest charts showed excellent basic accuracy, reflecting Hassler's painstaking efforts, but lacked much of the detail of the modern chart. A total of 169 charts was printed in 1844.

Surveys by this time had been extended into nine states. In 1845, reconnaissance preliminary to the survey of the coast of the Gulf of Mexico was begun and the coast between New Orleans

continued

A portion of the Chesapeake Bay and the mouth of the Chester River, as charted in 1849 (below, left) and in 1970 (below).





The brig WASHINGTON (upper left), a former revenue cutter, was the first Coast Survey vessel to be used extensively in oceanography. The chart of Martha's Vineyard and Edgartown Harbor was published in 1848.

and Mobile was thoroughly examined. Upon acquisition of the Oregon Territory from Great Britain in 1846, and the California Territory from Mexico in 1848, surveying the Pacific Coast of the United States became an added responsibility of the Coast Survey. The first such survey was started in 1848.

Rapid strides were made in copper engraving of charts for various coastal areas and harbors. Many of the copperplate engravings executed more than 100 years ago reflect the finest techniques in past methods of chart reproduction. The "age of copper engraving," which afforded a beginning to the career of the famed artist, James McNeill Whistler, was the most romantic period in American cartography.

With the acquisition of Alaska from Russia in 1867, hydrographic surveys were extended there, and later to the Philippines and Puerto Rico when they were acquired in 1898 from Spain. Hydrographic surveying is now carried on constantly along the Atlantic, Gulf, and Pacific coasts of the United States, in Alaskan waters, off the coasts of Puerto Rico, the Virgin Islands, Guam, and American Samoa, wherever the American flag and its commerce go.

The nautical charts issued by the Coast and Geodetic Survey were comparatively few. During the period from 1844 to 1861, 149,322 charts were printed, a modest output for the needs of a rapidly developing country. Annual production was limited to 10,000 to 20,000 charts. But with the onset of the Civil War, the number of charts printed rose sharply, with more than 245,000 being issued during the five years of the conflict. When hostilities ended, the agency readjusted to peacetime activities, its products now more appreciated.

New methods introduced in subsequent years made it possible for the Coast and Geodetic Survey to increase its chart production as its hydrographic ships accumulated more and more data on America's waters. Until 1905, charts were printed from engraved copper plates. The hand engraved copper plates were transferred by an electrolytic process to produce duplication that could be used for the actual printing, thus saving wear on the original engraving.

In 1905, photolithography was introduced. Lithographic stones containing photo impressions were used in special flatbed presses. Many more impressions per press hour resulted and the use of multicolors was facilitated. (Nautical charts now appear in five colors). Both production and accuracy were increased. It was now possible to use dry paper and eliminate much of the former distortion.

A greater improvement, however, came in 1916 when George Hoover, chief of reproduction in the Coast & Geodetic Survey, introduced the aluminum printing plate. This possessed the advantages of the lithographic stone, with flexibility that permitted its use on a rotary press. From the 75,000 copies printed in 1900, production increased to 330,000 in 1917. World War II saw a tremendous increase in chart production with nautical charts reaching an all-time high of 4,331,000 in 1945.

In addition to the nautical chart publications issued by the Coast and Geodetic Survey, approximately four million were issued by the U.S. Lake Survey, the Army Corps of Engineers facility in Detroit, Mich., which also became part of the National Ocean Survey in 1970. Its first publications were issued in 1841.

Just as the nation's burgeoning sea and lake commerce brought an urgent need for competent government-produced nautical charts, so did man's venture into the skies bring with it the need for aeronautical charts to aid the pilot in his flight above the often-hazardous terrain. With the first successful heavier-than-air flight in December 1903 by Orville Wright, the "age of aviation" began in the United States.

The first airplane pilots used road maps. As late as 1927, on his historic flight to Paris, Charles A. Lindbergh relied on various kinds of maps embellished with navigational lines.

Maps for flyers throughout the world were largely in the experimental and development stage when World War I began. Air war maps were produced largely by overprinting existing staff maps with air information.

In the United States, federal officials sensed the need for better air maps as the number of airplanes increased. Early in 1917, a paper was presented at a professional meeting by E. Lester Jones, Superintendent of the Coast and Geodetic Survey. Jones predicted that the day was not far off when his agency would conduct aerial surveying for the benefit of aeronautics.

The Army Air Corps first considered the needs for aeronautical charts in the early 1920's. In 1923, it issued the first sheets of a series of maps which was intended to include all the major air routes in the United States, and by 1927 some 44 strip maps had been produced. In 1926, the Navy Hydrographic Office issued the first sheet of a coastal air chart covering the route from Norfolk, Va., to Baltimore, Md. In 1931, the Army Air Corps published an aerial strip map covering the route between Wheeling, W. Va., and Richmond, Ind.

In 1926, Congress authorized the Department of Commerce "to provide as adequate charts for air navigation as it now provides for ocean navigation." The task was delegated to the Coast and Geodetic Survey which has since then, along with its successor agency, the National Ocean Survey, produced most of the nation's aeronautical charts.

Under the direction of Casper M. Durgin, first chief of the Aeronautical Chart Section, the agency issued its first aeronautical chart in 1927, covering the route from Kansas City to Moline, Ill. By the end of the year, six new charts had been published.

The period from 1930 to 1939 constituted a time of steady growth in the aviation industry for military, commercial, and private flying. Navigational equipment on the ground and in the cockpit improved. By 1939, there were 27,074 miles of airways equipped with facilities for radio navigation and communication.

These growth factors resulted in a large increase in the amount of information vital to the pilot that had to be shown on aeronautical charts. The agency met that challenge and those of the years that followed, including the urgent demand for aeronautical charts during World War II when 16,900,000 were issued in 1945 alone. During this conflict, all the cartographic resources of the nation were combined to meet the needs for air maps and charts, including the Army, Geological Survey, the Coast and Geodetic Survey, and several units within the Department of Agriculture.

At war's end, the task reverted to the Coast and Geodetic Survey, and since then the agency has produced aeronautical charts for both civilian and military use.

In the years since 1926, the agency has compiled, printed, and kept current multiple aeronautical charts. These include large-scale charts for use in piloting and contact flying; small-scale charts for use in the navigation of high-speed transports; special charts for radio navigation; and charts for instrument approach and landing procedures. All these charts, despite their diversity, have air navigation usage for their common purpose.

In 1945, the government requested that a new series of charts be prepared for a different purpose, the safety regulation of aircraft. Civil Aeronautics Board regulations prescribe maximum weight limitations for air transports. These limitations vary with the type of aircraft, wind conditions, the length, elevation, and grade of the runway being used, and the locations and elevations of obstructions in the vicinity. To study these latter factors governing weight limitations, the agency designed a new series of Airport Obstruction Charts.

Today, the agency carries out aerial surveys which crisscross the entire country. Indicative of the progress that has been made in this area in less than a half century, the aerial photos are of such high resolution that they provide a portrayal of topographic features in a minute detail that was unheard of only a comparatively few years ago. □

Better communications, greater individual and community preparedness, proper anchoring of mobile homes, and improved building codes are needed to lower the tornado death toll, says Allen Pearson, Director of the Weather Service's National Severe Storms Forecast Center.

TORNADO CENTRAL USA

Allen D. Pearson not only heads the National Severe Storms Forecast Center but also is Meteorologist in Charge of the Kansas City Weather Service Forecast Office, one of the largest in the nation.

Born at Mankato, Minn., in 1925, he attended the University of Minnesota and was graduated from the University of California at Los Angeles in 1946 with a B.S. in meteorology. Later, he studied advanced meteorology at the University of Hawaii.

After serving as a meterological officer in the U.S. Navy, Mr. Pearson worked for several years as a forecaster-dispatcher for Pan American Airways. In 1951, he joined the National Weather Service at Honolulu. With the exception of a two-year assignment to Wake Island, he remained at Honolulu until 1964, when he was appointed chief of the Emergency Warnings Branch at Washington headquarters. In July 1965, he moved to his present post in Kansas City.

Q. Mr. Pearson, could you tell us a little about the National Severe Storms Forecast Center—where the idea for it came from, how old it is, and so on?

A. Gladly. The Severe Storms Center was established about 20 years ago to provide a central, specialized unit to predict on a broad scale where outbreaks of severe local storms—primarily thunderstorms with tornadoes—are likely to occur. It concentrates the effort for doing this in one place.

Q. Aren't these storms so small in scope that such forecasts could be handled by local weather offices?

A. It's a partnership. We provide the centralized view; they take it from there, providing more detailed forecasts for their localities.

Q. Could you tell us more about your specialty?

A. The key words are "severe" and "local." We call the main component of the Center the Severe Local Storms Unit—SELS, for short.

Q. Could you describe this unit?

A. SELS usually has seven people on duty at any given time of day or night—two forecasters, two communicators, two radar analysts, and one computer operator. They watch 48 states.

Q. What do they look for?

A. Conditions that will produce severe thunderstorms which, in turn, will spawn tornadoes. We know that severe thunderstorms tend to form in masses of unstable air—where there is a large temperature spread between warm surface air and cold upper air. Also, there must be a certain amount of moisture available in the lower atmosphere and a certain amount of wind shear—that is, winds moving in contrary directions—between lower and upper levels.

Put maximum numbers on all these elements and you have ingredients for trouble, although you can't tell precisely where individual storms will develop.

Q. Why is the Midwest the area hardest hit by tornadoes?

A. Lets correct that idea right here. It's a common misconception. The tornado zone is more than the Midwest; it's the Deep South also. There's what I call the Dixie tornado alley that runs from Louisiana through central Mississippi into Alabama and northern Georgia. That area has had some of the most devastating tornadoes in our country's history. Examples are the Mississippi Delta tornadoes of February, 1971, in which 130 died; the Hazelhurst, Miss., storm in 1969, with 32 deaths; Jackson, Miss., in 1966, with 57; and Gainesville, Ga., in 1936, with 203. Actually the highest death tolls over the years have been in the South, rather than the Midwest.

Q. I'll amend the question. Why are tornadoes more frequent in the South and Midwest than elsewhere in the U.S.?

A. Three main reasons. The Rocky Mountains tend to accentuate winds moving northeastward on the lee side producing a cold dry current that we call the mid-level jet stream. Second, the Gulf of Mexico provides an abundance of moisture-laden air moving up from the south and finally the Rockies prevent the moisture from moving west, concentrating it ahead of the mid-level jet. Where these contrasting types of air meet you get severe thunderstorms and tornadoes. Eliminate any one of the factors and there wouldn't be much trouble.

Q. Isn't the flat terrain a factor, too?

A. Yes, it is. Friction from forests, hills, and mountains tends to weaken any kind of storm.

Q. Do you also worry about severe winter storms, the ones that produce blizzards?

A. These are not SELS' department, although we're interested in them as meteorologists, of course. A large winter storm may produce snow, rain, or ice over tens of thousands of square miles, whereas a severe thunderstorm with damaging winds, tornadoes, and hail may be concentrated in an area of only five to ten square miles. Our specialty is the tiny, ferocious storm of great social and economic significance—especially the tornado.

Q. How do the killer storms—hurricanes and tornadoes—compare in frequency and impact, nationwide?

A. Well, on the average, there are only a couple of full-blown hurricanes a year that affect the United States, and of course there are many states that are never affected by hurricanes. But every state at one time or another has had a tornado, although some states have many more than others.

Looking at it another way, on about 150 days a year there is a tornado somewhere in our country, whereas hurricanes probably don't directly affect the U.S. mainland more than six or seven days a year, on the average.

The other side of the coin is that, although the tornado is an extremely vicious whirlwind with winds of up to 300 miles an hour, it affects only a few square miles, usually. The hurricane, with circular winds blowing perhaps 100 miles an hour and rarely as much as 150, may affect thousands of square miles as it moves inland or parallels a coastline. Also, hurricanes tend to strike densely populated coastal areas while tornadoes more often strike rural areas that are less densely populated.

Q. How many tornadoes are there in the United States each year, on the average?

A. Let's make a distinction between how many we believe there really are and how many of those are reported. The average yearly total since our present system of reporting was begun in 1953, is 642. The peak year of record for tornadoes was 1967, with 912; a recent low year was 1963, with 461. I'm expecting reports this year to total about 850, when the official tally is in. In a few more years I feel sure we'll top 1,000.

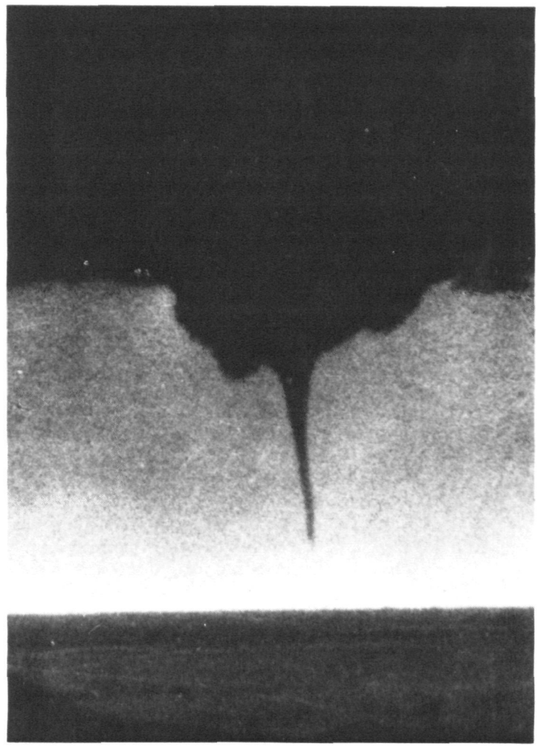
Q. What would you expect the actual total would be if all the tornadoes that occur were reported?

A. I would think between 900 and 1,000 a year—again, with wide fluctuations from one year to the next. Wide fluctuations in frequency are characteristic of tornadoes, one of many erratic things about them. In our Kansas City area, where we have a very fine network of volunteer spotters, we have had some years with as few as five or six tornadoes, other years as many as 20 or 30.

Q. How about death tolls from the two kinds of storms?

A. Here again, there are such large fluctuations that averages tend to be misleading. During the 20-year period 1951 through 1970, there were 65 hurricanes and lesser tropical cyclones that killed 1,456 people—an average of 73 a year. During that same period, 12,604 tornadoes killed 2,351 people—an average of 118 a year. But note that individual years for hurricanes varied from 1951, with no hurricane deaths, to 1957, with 395; and, for tornadoes, from 1953, with 516 tornado deaths, to 1963, with only 31.

continued

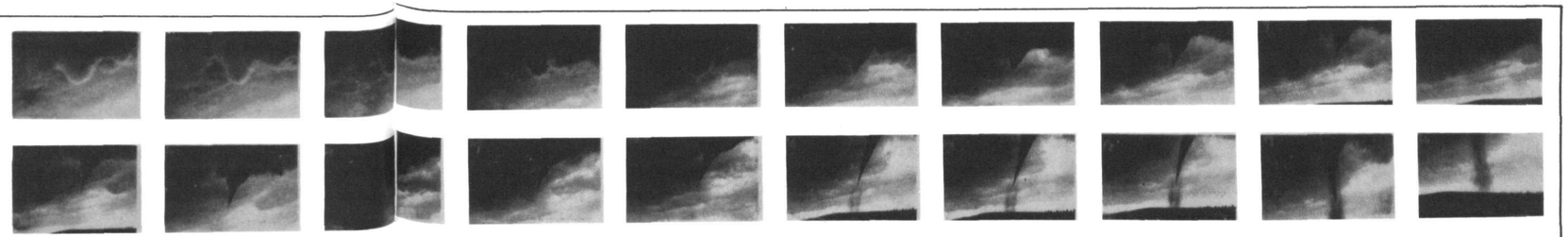


Tornado at Morse, Texas June 9, 1971.
Photo by Larry Nance, Borger News-Herald.

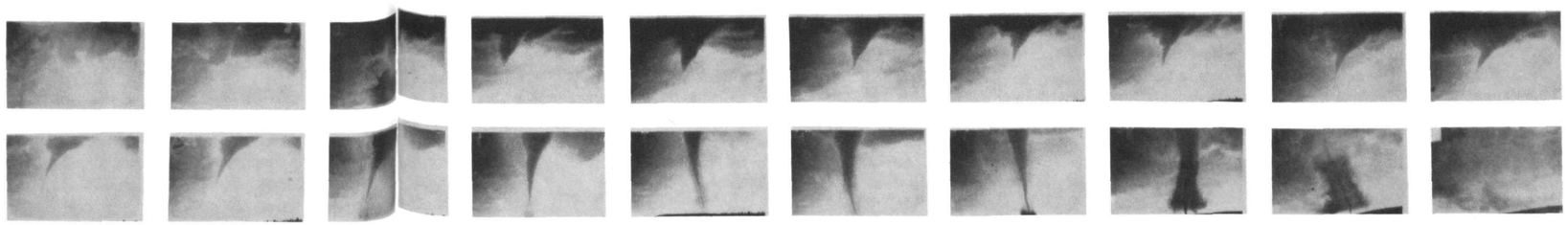
ELLSWORTH, KANSAS TORNADO

MAY 11, 1970

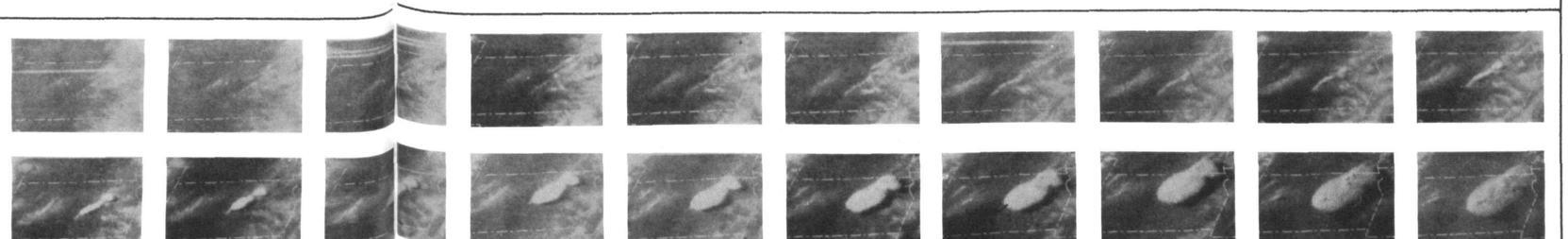
Pictures taken about 19 miles northeast of Ellsworth about 7:08 to 7:20 PM CDT by Trooper Henry Perez, Kansas Highway Patrol.



Pictures taken about 16 miles northeast of Ellsworth about 7:20 to 7:32 PM CDT by Trooper L. Vernon Davis, Kansas Highway Patrol.



Portions of NASA ATS 3 satellite pictures showing cloud growth over Kansas.



Q. How about thunderstorms? How many of these occur annually in the U.S.?

A. Too many to count, tens of thousands at least. Of these, several thousand would classify as severe thunderstorms, with damaging winds and hail. We classify severe thunderstorms as those with winds of 50 miles an hour or greater, or at least three-quarter-inch hail.

Q. A storm like that can do a lot of damage, can't it?

A. Indeed it can. And that's one of our problems in keeping records—trying to determine just what hit a locality. A downrushing wind out of a thunderstorm will frequently hit 80 to 90 miles an hour and make a lot of noise. People think they're hearing a tornado. And it may also have twisting or shearing forces that cause debris to fall in a chaotic fashion. The truth is, straight-line winds from thunderstorms often produce damage that looks very much like a tornado's. This sort of thing is more common than most people realize.

Q. How about hail? What is its effect?

A. Tremendous. Although hail doesn't kill many people, severe thunderstorms with hail probably produce two or three times as much dollar damage as tornadoes. Hail is devastating to crops such as fruit, tobacco, soybeans, barley, rye, wheat, corn, cotton, sugar beets, potatoes, and sorghum. And it's rough on airplanes in flight.

A recent study indicates that, from the standpoint of dollar losses, the biggest of all weather problems in this country is drought, and next is hail.

Q. Lightning is a problem, too, isn't it?

A. Yes. We believe lightning kills more people than tornadoes. Total reported deaths from lightning run something more than 100 a year, but the picture probably is not complete. Many fire deaths are probably from lightning-caused fires, but they don't show up that way in vital statistics. And even deaths from direct strikes by lightning are difficult to total. These usually involve only one or two people at a time. They're not big news. Statistic-gatherers probably don't hear about all of them.

Q. How do you, as forecasters, translate what you foresee in possible severe weather to information useful to the public?

A. By our SKYWARN system of watches and warnings. When we issue a severe-storm watch, we're telling people that the storm is likely to occur in their area. When we issue a warning, it means we believe it's on the way. The system is far from perfect, of course. Severe local storms are too brief and erratic for perfection. The smaller tornadoes are particularly troublesome. These frequently last about 10 minutes and cover a path perhaps an eighth of a mile wide by two miles long. All too often, by the time the report gets into the communications system and out over the air waves the tornado is over, leaving a trail of death and destruction. That's why the watch was developed, to give people some idea that a threatening condition exists, even though we can't say exactly where or when. Some people criticize this because it's vague, but we believe most people appreciate the knowledge that the possibility exists, even though it frequently or probably won't materialize.

Q. What should people do when a tornado watch for their area is announced over the radio? Run down in the basement and hide?

A. No. That's not the idea. During a watch, we recommend that people go about their business as usual, but keep tuned to radio or TV for storm bulletins and keep a weather eye on the sky. Even if the sky overhead is clear, it's a good idea to scan the horizon occasionally for a line of low, threatening clouds—what we call a squall line. These often produce tornadoes. In open country, a tornado can sometimes be seen miles away.

A typical situation might be where the Severe Storms Center has issued a tornado watch for an area, say, 60 miles on either side of a line from town A to town B, and the local weather office follows this with a severe-thunderstorm warning for that area. That might be the forecaster's way of saying: "This storm is building up rapidly; it is capable of producing at least damaging straight-line winds and possibly a tornado."

Q. What would you do in that situation?

A. Stay close to suitable shelter and stay alert. And if I were sitting in a mobile home that was not tied down securely I would certainly seek better shelter. We forecasters are all too familiar with the spectacle of unsecured mobile homes which have been rolled over by strong winds. Even a thunderstorm can do that to a mobile home that is not tied down, but just sitting on blocks. With proper tiedowns, I'm told that mobile homes can withstand strong winds without overturning. We still would recommend, however, evacuating them when winds of hurricane force—75 miles an hour or greater—are expected. Such winds can fill the air with flying debris that might pierce or crush the walls of a mobile home.

For this reason, we recommend that mobile-home parks have a designated community shelter where residents can assemble during a storm warning. Wardens should be appointed to monitor radio and TV for bulletins and to keep an eye on the sky when weather alerts have been issued. I would hope also that the residents would get together and purchase a little hand-cranked siren to sound an alarm. This rather simple type of community preparedness would do a world of good in mobile-home parks.

Q. If there were enough time, couldn't the mobile-home owner move his trailer to a place of safety?

A. No. That's just not practical, even if it were a good idea, which it isn't. The modern mobile home is a far cry from the little travel trailer. It's not something you can hook up to the family station wagon and trundle down the highway on a few minutes' notice. The mobile-home communities now springing up so rapidly all around the country consist mostly of units meant to be moved only once—from factory to place of installation, by truck, not car. These units are quite large, frequently 12 by 60 feet, and furnished from top to bottom at the factory. The industry is beginning to call them manufactured homes to de-emphasize the idea of mobility. There also is a movement underway to lessen their vulnerability to windstorms by insisting on over-the-top tiedowns of steel cable or strap, anchored to holdfasts imbedded in concrete or sunk deep in the soil. Ordinances are being passed in some localities requiring tie-downs. We're in favor of these. Good

continued

tie-downs are not very expensive. Proper anchoring, for example, might have saved many of the several thousand mobile homes that were rolled over and demolished during Hurricane Celia in 1970. Since then, Corpus Christi has passed an ordinance requiring tie-downs. They're also required in Kansas City and in Wichita.

Q. What do you recommend for people in general during tornado-watch periods?

A. The first thing they should know is whether their town or city has any means of sounding an alarm, perhaps by siren, if a tornado has been spotted bearing down and a warning issued by the local weather office. Many towns don't have such an alarm system, I'm sorry to say, even where tornadoes are fairly common. Other towns won't sound a siren until the tornado is right on top of them.

Whatever the system, people should know what it is.

And of course there's always the chance that there won't be sufficient time for any kind of warning to be issued. This is why we suggest that people stay alert and watch the sky.

Q. What should they look for? A funnel cloud like we've all seen portrayed in "The Wizard of Oz?

A. I wish it were that simple. Unfortunately, the funnel cloud is often obscured by driving rain or clouds of dust, or completely invisible because it forms after sundown. To allow for all these variations we suggest that, in daytime, people watch for a sudden darkening of the sky, perhaps accompanied by a rapid increase in wind noise, pounding rain, hail, and lots of lightning and thunder —as well as a funnel cloud. When it's night, listen for a loud roar like a freight train or a formation of jet planes. This is the characteristic sound of a tornado.

When in doubt, take cover.

Q. How far away could you expect to hear a tornado?

A. Maybe a couple of miles. It depends on its size and stage of development. In some instances, people heard nothing out of the ordinary before their houses began to fly apart. Usually, though, I think you might hear intense noise several minutes or so in advance.

When you become suspicious, it's a good idea to turn off the air conditioner and open a window on the side of the house away from the wind. Then you can hear an approaching tornado without getting a roomful of rain and also be ready for an abrupt drop in pressure as a tornado passes by. This could keep your house from exploding.

Q. If I'm down in the basement and a tornado collapses the house on top of me, isn't there a big danger of fire or suffocation?

A. I'm amazed by the scarcity of reports of fires following tornadoes, or of people being suffocated, asphyxiated by gas, or electrocuted by downed wires. There just is not very much of that sort of thing.

One important rule to avoid getting trapped is to stay away from walls put together with mortar, if you can. A solid wall generally will hold.

Q. Would it be a good idea, then, to stay away from a chimney?

A. Yes, because there is mortar in it. All it takes is for one mortar joint to go and the whole thing does. If you're building a house and you have a choice between a mortared wall and a poured-slab wall in the basement, I would insist on the latter. There's hardly any difference in cost.

Q. Do you have special suggestions for construction in tornado alley?

A. I would suggest realistic building codes such as they have for hurricanes in Miami. We can recommend sources of information for builders who want advice.

Q. In homes without basements, why do you recommend hiding from tornadoes in closets and bathrooms?

A. In our post-tornado surveys, we often see first-floor bathrooms and closets standing by themselves, with the rest of the house flattened. Bathrooms are especially resistant. All those pipes for plumbing provide extra strength.

Q. What about hiding under the bed?

A. Not unless the bed has extra-solid framing; otherwise the whole thing might collapse on top of you. But you might yank off the mattress and pull it over the top of you.

Q. Suppose I'm driving along in my car and I see a tornado headed toward me, should I try to outrun it?

A. Not if it's a really powerful tornado. Some of the tornadoes in Mississippi last February moved ahead at 70 miles an hour. If you were to try to outrun such a tornado and it were right behind you traveling in the same direction, you would have to drive at least 80 miles an hour. Try to imagine that, over roads slick with rain, clogged in spots with slower-moving traffic.

Q. What would you do instead?

A. First, I would try to decide if the tornado was on a collision course. You can tell by observing if it seems to be getting closer—growing larger—and stays at the same angle in relation to the car. If I saw this, I would stop, get out of the car and go lie down in a ditch.

Q. Wouldn't this expose you to flying debris?

A. I'm not aware of many instances where people have been killed by tornadoes when they were lying down. In my view, staying in the car would be yielding to a false sense of security.

Cars become unstable in a strong wind, easily blown off the road and rolled. Even in winds of 40 miles an hour, a car gets hard to handle. The outer fringes of a tornado will produce winds of 60 to 70 miles per hour, and if you're moving at that same speed trying to escape, it seems to me that's a formula for disaster.

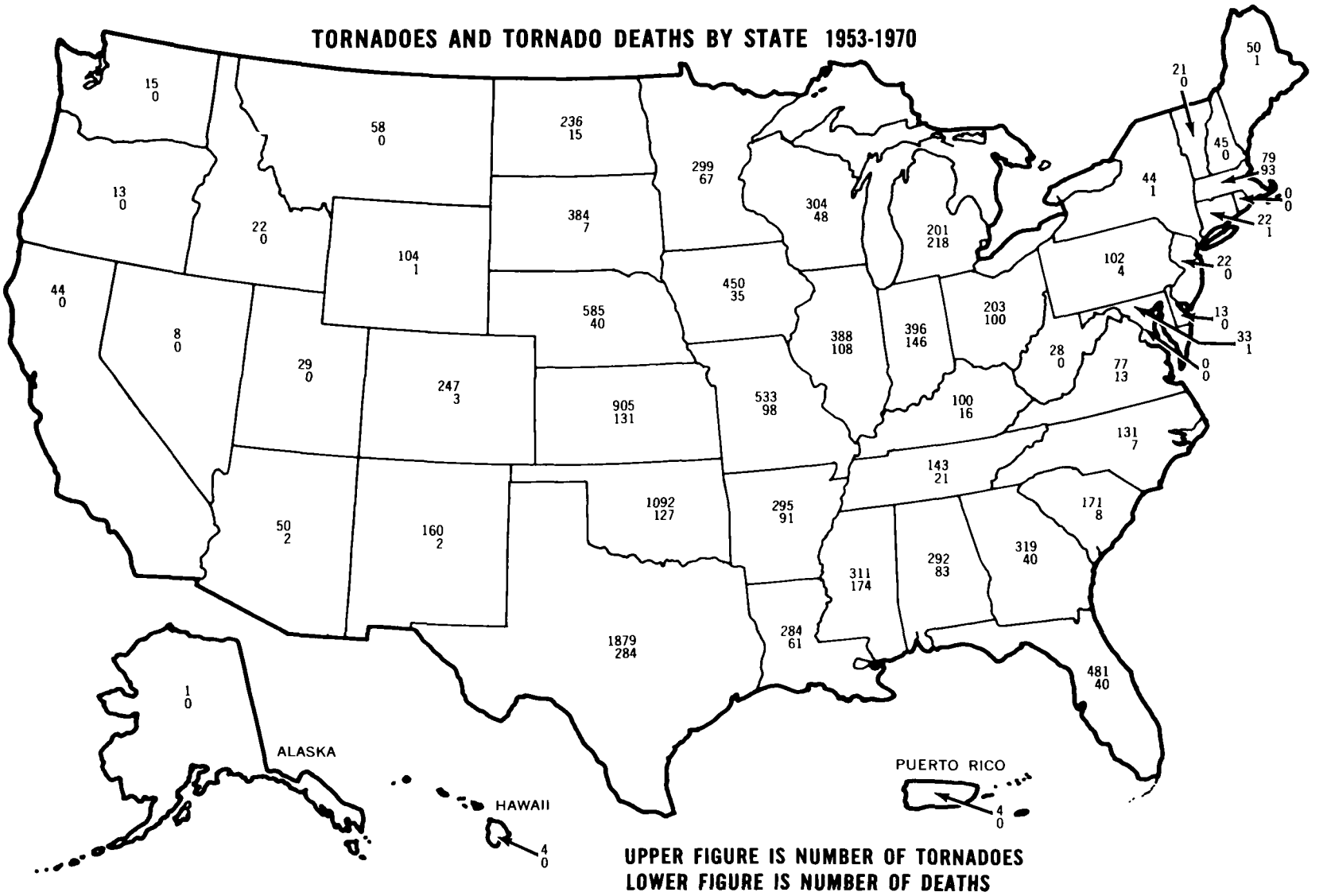
Q. What is your greatest need, in warning people about tornadoes?

A. Better communications. Right now, even in the heart of tornado alley, when forecasters get word of a tornado, it takes a minimum of five minutes to get that information out over our own weather wire to radio and television stations which must broadcast the warning.

In some states which have a weather wire, less than half of the media subscribe. Other tornado-prone states—Nebraska is a case in point—have no weather wire. Finally, these are hundreds of good-sized towns in this country that don't even have a radio or television station. How do you alert these towns?

Q. What's your recommendation?

A. I would like to see a dedicated communications link connecting every National Weather Service office to the National Severe Storms Forecast Center here in Kansas City. I would also like each Weather Service Office to have an instantaneous communications link with every sheriff, police chief, and fire department in the areas that they serve. And when I say instant, I mean just that. Press a button: instant communication.



Q. Do you think there will come a day when everybody in the country will be covered by a totally effective tornado warning system?

A. No. I think the National Weather Service will have to concentrate on providing warnings for the cities, where people are concentrated. That's where the big tornado tragedies occur. We'll never have the resources to do a complete job in rural areas as well. People wouldn't be willing to pay for it. Besides, farmers tend to be much more weather conscious than their city cousins, and usually know how to take care of themselves.

Q. Even in cities, though, where you have warning systems, there are lots of people who work in factories, stores, hospitals, and schools who don't have the opportunity to monitor radio and TV during a watch period—or to keep looking out the window all the time. What about them?

A. I would like to see hot-line communications into all places where there are concentrations of more than 100 people. When people are massed together and preoccupied with other assigned tasks or interests, they deserve to have someone looking out for them. I live in dread of the day when a tornado bears down on a large sports stadium to which everybody came by private car.

Q. What are your needs in detecting tornadoes? Do you need more volunteer spotters?

A. Yes, lots of them. And they must be better trained than they are now. The human eye is still the best means of detecting tornadoes.

Q. Does radar help you a lot in forecasting tornadoes?

A. Definitely, but it's not foolproof and not the panacea that some members of the public assume it to be. Radar just gives the operator a clue, so that he may suspect that a given thunderstorm is big enough and tall enough to have definite potential for a tornado. But radar doesn't say exactly where, when, and for how long the tornado will occur.

Q. We hear a lot about a hook echo being associated with tornadoes —that is, a hook-shaped pattern on the radarscope. Is that reliable?

A. The hook echo has been oversold. It is not always there on the scope when a tornado has formed, and, if it does appear, frequently by that time the tornado is already on the ground. Sometimes it's difficult to distinguish a hook from a harmless appendage—and we cry "wolf" for a tornado that doesn't exist. What the forecaster needs is something that gives him a reliable, five-minute lead on tornado touchdown.

Q. How about satellites?

A. The satellite has been very helpful in some situations in springtime, but, as you get into summer, there tends to be more and more cloudiness over the country, making it nearly impossible to locate all the thunderstorms that might have tornado potential.

Q. Suppose you had another outbreak of tornadoes like the 47 that raked the Midwest on Palm Sunday of 1965. Do you think your present warning system would result in far fewer than the 270 deaths that occurred then?

continued

American Red Cross photo by Jack Shere

(Left) Proper anchoring might have saved many of the mobile homes that were demolished during Hurricane Celia. (Above) Tornado damage in Greenwood and Jonesboro, Arkansas, in the spring of 1968.

A. Yes. But there still would be a lot of fatalities. Those tornadoes were longer lived and more severe than most. The distressing thing about the Palm Sunday type of outbreak is that in a single state there may be five or six really vicious tornadoes going on at about the same time. This overtaxes weather offices and the radio and TV warning system. People hearing the reports tend to be overwhelmed by words. They don't know what to do, or when to do it.

Q. What's the best example so far of a tornado warning that saved lives?

A. We think the classic warning, from start to finish, was for the Topeka, Kansas, storm of June 8, 1966. That tornado did an immense amount of damage to property but killed only 17 people.

A tornado watch was issued well in advance by Joe Galway, my deputy. The cloud that produced the tornado was tracked by both the Topeka radar and the Kansas City radar. Topeka had a fine volunteer spotter organization. Spotters were in the right position. They saw the tornado touch down west of town. They sounded a warning by means of a good siren system. Radio and TV stations interrupted their broadcasts to spread the alarm. The tornado was on the ground for about 22 miles and went right through the heart of town. Result: There were 12 tornado deaths and five heart attacks—all this in a city of 100,000 people.

Q. How many do you suppose might have died without the warning?

A. More than 100. In my view, that saving of lives paid for the entire tornado-warning system for that year and many years to come.

Q. Do you have such gratifying results frequently?

A. Yes we do, although there aren't many so clear-cut as the Topeka incident.

Q. I know you get a lot of complaints from people who don't like being alerted so often about the possibility of tornadoes when their chances of being affected are so slim. What's your answer?

A. I tell them the story about the little old lady who, on hearing her first tornado watch announced, mistakenly rushed down to the basement and hid under a workbench, trembling with fear. When no tornado appeared, she telephoned the forecaster and scolded him at great length for upsetting her, brushing aside his explanation that she misunderstood the procedure for a watch. A few weeks later a second tornado watch was issued and down to the basement she went again. Nothing happened, and again she scolded the forecaster.

A month went by, and a third watch was issued. She hid again, with much grumbling. This time the tornado utterly demolished the little old lady's house, leaving nothing but the basement. She fought her way up out of the rubble, tottered down the road to a neighbor's house, dialed the forecaster and crowed:

"Well now! That's more like it!" □

(An editorial reprinted from the TOPEKA CAPITAL, June 23, 1971)

The National Weather Service is not just crying "wolf" when it issues storm warnings. There always is potential danger.

Yet, only a little more than five years after Topeka's destructive tornado, many people are beginning to forget that it was the warnings which helped save lives at that time.

For a while after that tornado, people took cover whenever the sirens sounded and kept close to their radios and TVs when storm warnings were issued. Now, many even grumble that there are too many warnings.

Listen to the Weather Service side of the story. They say thus far this season has been one of numerous funnels and brief tornadoes, but with only spotted and mostly light damage in the Northeast Kansas area. Each situation has presented a potential threat, both from the standpoint of brief localized damage to the risk that development may extend to the intense tornado that results in devastating damage along an extended path. Many of the storms have been borderline to a much more serious tornado. Although the National Weather Service tries to use a great deal of discretion in issuing warnings, these are released as necessary in situations that present a potential threat to the public safety.

Forecasting the exact location and extent of a tornado is impossible, although the science of weather prognosticating has advanced greatly in recent years.

If conditions are such that a tornado appears to be impending, the Weather Service is only doing its duty in sounding an alert. Think of the howl that would rise if no alert were issued and a tornado struck a populated area.

It does seem that the warnings have come pretty often so far this year but it has been a season when storms were frequent. To ignore them would be folly.

TORNADO SAFETY RULES

When a Tornado approaches—Your immediate action may mean life or death. Seek inside shelter, preferably in a tornado cellar, underground excavation, or a steel-framed or reinforced concrete building of substantial construction. **Stay away from windows!**

IN CITIES OR TOWNS

In Office Buildings

Go to an interior hallway on the lowest floor, or to the designated shelter area.

In Factories

Workers should move quickly to the section of the plant offering the greatest protection in accordance with advance plans.

In Shopping Centers

Go to the designated shelter area—not to your parked car.

In Homes

The basement offers the greatest safety. Seek shelter under sturdy furniture if possible. In homes without basements, take cover in the center part of the house, on the lowest floor, in a small room such as a closet or bathroom, or under sturdy furniture. Keep some windows open, but stay away from them!

Mobile Homes

Mobile homes are particularly vulnerable to destructive winds. Proper tie-downs to prevent overturning will minimize damage. A warden should be appointed in mobile-home parks to scan the skies and listen to radio and television for warnings. There should be a designated community shelter where residents can assemble during a tornado warning. If there is no such shelter, do not stay in a mobile home during a tornado warning. Seek refuge in a sturdy building or a ditch, culvert ,or ravine.

In Schools

Whenever possible, follow advance plans to an interior hallway or the lowest floor. **Avoid auditoriums and gymnasiums** or other structures with wide, free-span roofs. If a building is not of reinforced construction, go quickly to a nearby reinforced building, or to a ravine or open ditch and lie flat.

In Open Country

If there is no time to find a suitable shelter, lie flat in the nearest depression, such as a ditch or ravine.

KEEP LISTENING

Your radio and television stations will broadcast the latest National Weather Service tornado watches and warnings, and inform you when the danger is over.

WATCH THE SKY

Tornadoes come and go so quickly there may not be time for a warning. During a tornado watch, be alert for the sudden appearance of violent wind, rain, hail, or funnel-shaped cloud. When in doubt, take cover. Tornadoes are often obscured by rain or dust. Some occur at night.

REMEMBER:

Tornado Watch means tornadoes are expected to develop.

Tornado Warning means a tornado has actually been spotted. Persons close to the storm should take cover immediately. Those farther away should take cover if threatening conditions approach.

NOAA Profile

MAN OF ACTION

BY EILEEN WEPPNER

Ask tall, spare Roger Olson "how's the weather up there?" and you may be answered in unearthly terms of sunspot activity, solar flares, and radio bursts, and X-ray and proton events. A research meteorologist with NOAA's Environmental Data Service in Boulder, Olson is currently on loan to the National Center for Atmospheric Research (NCAR), where he and Dr. Walter Orr Roberts are studying the possible effects of sun-induced magnetic storms upon the earth's weather patterns.

Working in NCAR's offices atop a 600-foot mesa, where the amenities include occasional herds of curious deer and a spectacular view of Boulder and the Front Range, Olson pores over pressure gradient maps from the 300-millibar level of the atmosphere, some 30,000 feet above the earth. Here the jet stream, a fast-moving river of wind found only in temperate latitudes, whips eastward at speeds ranging up to 150 to 200 miles per hour. Olson analyzes 300-millibar maps from a Gulf of Alaska target area for low-pressure "troughs" whose sharp changes in air pressure over short distances indicate the jet stream's presence. He is looking for evidence that troughs tend to appear and "deepen" following displays of the Northern Lights or the magnetic storms which usually accompany them.

"It's just old-fashioned meteorology," he says, with characteristic self-deprecation. "I've got a lot of dull, routine work to do, map after map, measuring parameters. Vorticity (the atmosphere's rate of spin around a low-pressure area) is sort of an elusive thing, but calculating it on a computer makes it much more objective. Dr. Roberts does the magnetic analyses, to determine whether an auroral event has occurred, and then we put the trough data and the magnetic data together, trying to re-analyze the subtle aurora-trough relationship."

If the NCAR project can not only establish that the earth's winds are intensified by barrages of protons and electrons from the sun, as some evidence already suggests, but—if this is the case—can also explain exactly how it occurs, then sunspots, flares, and other solar weather may eventually be of routine meteorological concern, and "the weather up there" will include storms that are some 93 million miles distant, and larger than the earth itself.

But churning solar storms and wind patterns far aloft are far from being Roger Olson's whole life. His more down-to-earth interests include a lively family of five children, Boulder's nationally recognized Attention Homes for teenagers, atmospheric physics students at the University of Colorado, and, most recently, environmental action groups.

Pedaling from his home on Sunset Hill through central Boulder and on up the steep, winding road to NCAR mesa, Olson seems as hardy, self-sufficient, and at one with nature as any of his Norwegian forebears who sailed the northern seas, and were themselves well

On the job, Roger Olson studies the tie between solar storms and weather. But his concern for the human environment extends much further.

versed in practical meteorology. But despite a Scandinavian economy of expression, and the upright bearing of a former Air Force lieutenant colonel, Olson impresses friends and family alike as sensitive, compassionate, and responsive to the needs of others.

Whether interviewing prospective Attention Home houseparents, listening to a student, reading to nearly blind Grandpa Ole, or making a point at a NOAA conference, Olson follows other people's reactions attentively.

Always calm, he is also widely characterized as patient. His wife Phyllis, a brisk New Englander, quick and efficient in word and action, emphasizes the contrast between them: "Roger is very patient; I'm not, though I'm getting more so. I've only heard him cuss once in 25 years."

His patience, however, is the taut patience of a retriever waiting for a stick to be thrown. He listens for that moment when the talk will finally reveal an opportunity for action. Such a moment came in 1965, when his First Methodist Adult Sunday School class originated the idea of Boulder's Attention Homes, three of which now offer a temporary or long-term home for teenagers who have committed minor offenses, been in trouble in school, or suffered severe family conflicts.

When the Olsons joined the class in the fall of 1965, they had been in Boulder only a year. After retiring as head of the Solar Prediction Service at Scott Air Force Base in Illinois, Olson had assumed the task of setting up a Solar Forecast Center for the Environmental Science Services Administration—now NOAA's Space Environment Forecast Center.

In the Sunday School class, Olson at first said little. Then the discussion turned to local social issues, and probation officer John Hargadine spoke to them of the need for "attention—not detention—for troubled youth." He described the appalling conditions under which juveniles were being held in the Boulder County Jail, often on very minor charges, or in some instances not as a result of any offense at all, but simply for lack of physical safety or basic necessities in their own homes. Soon Olson and several other class members were meeting at weekly lunches to get the first home opened.

Starting as vice president of the Board in January 1966, a position to which he has been re-elected this year, he was elected to a one-year term as president in the summer of 1967. He has served on the executive committee and as head of personnel, and has also remodeled rooms, installed carpeting, taped a talk on the Homes, written their history, and, with Phyllis, played host to innumerable visitors who have come to learn more about the Homes.

An Attention Homes pioneer who has worked closely with Olson says: "What Roger is interested in is getting the job done, and done right. When the customary crises came—no money, no houseparents, runaways, no one to take the week-end shift—if there was no other immediate answer, it would be, 'Well, Phyllis and I will take the kids.' His dedication and willingness to give everything are 100 percent; there's no holding back. I remember seeing him in the basement of the Pine Street home, helping dig it out from just a coalbin, along with 30 prisoner volunteers from the jail."

"You can see a change of philosophy taking place in this country," Olson believes. "My Dad is an old pioneer who came over from Norway, lived in a sod hut, suffered, and almost starved. His generation certainly tried to help other people, but things back in those years were not very well organized, and the prevailing work ethic was that people who are poor, unemployed, and on relief want to be

(Opposite page) At the Pine Street Attention Home, Roger (left) and Phyllis Olson (right) talk with houseparents Sande and Dave Johnson.
(Above) Three generations of Olsons—Grandpa Ole, Roger, and Richard.

that way. That type of thinking ignores the fact that circumstances can preclude some people from helping themselves without a hand from others. I think now people are more sympathetic."

Olson's activism has not been at the expense of his family. Friends marvel at the Olson children, who are lively and unselfconscious, yet unusually independent and mature. Twenty-four-year old Steve, after Army service including a tour of duty in Vietnam, lives and works in Denver, where he also attends business school. Barbara, 22, is enrolled in the five-year program of the University of Colorado School of Nursing, also in Denver, and Christine is at the University of Washington in Seattle as a junior music major. Still in Boulder are Jim, a recent Boulder High School graduate, and three-year-old Richard, who gives early promise of being the most extroverted Olson of them all.

Geographical stability has played no part in creating the family's close ties; the Air Force kept them almost constantly on the move before they came to Boulder in 1964. Olson joined the Army Air Force Cadet program in 1942, after completing an A.B. in geology at the University of Wyoming. He elected the meteorology specialization, and spent most of the war years as a forecaster at Goose Bay, Labrador. In 1945, while stationed at Bangor, Maine, he met Phyllis on a blind date. The diminutive Montgomery Ward credit manager and the lanky meteorologist married in 1946, after he had completed his Air Force service.

After taking a master's degree in geography at the University of Wisconsin in 1947, he taught for a year at Texas A & M, then took an advanced course in meteorology at Chanute Field on a reserve status basis.

"He found they needed teachers and re-enlisted in 1948," explains Phyllis. "We never lived on a military base; we lived as civilians. He had to wear a uniform, that was all. We owe a great deal to the military for the education he received while we were raising a family."

continued

Of his outlook on teaching for the Air Force and, more recently, the University of Colorado, Olson says: "The four years of teaching for the Air Force may well have been the most valuable period of my entire career. Teaching and writing are really the things I'm interested in; I don't think in terms of being a dedicated research type. I like more operational work, applied to a problem of some sort. The atmospheric physics course at CU in the fall of 1970 was very nice in connection with the project at NCAR; teaching refreshed me on theory I needed in the research, and I also used the research results in talking to the students."

After receiving his M.S. in meteorology from St. Louis University in 1954, and commanding a small Air Force weather facility in England, Olson came to Boulder and the University of Colorado Astro-Geophysics Department in 1959 as the first military man to enter the space weather program.

"I was a 40-year-old major going to school with 25-year-old graduate students," he recalls. "Dr. Roberts was in charge at that time, and there were only 10 or 12 students, meeting in Quonsets on the campus."

Olson then used his two years of training at CU to organize a solar forecast center for Scott Air Force Base in Illinois. When the Environmental Science Services Administration decided to set up a Space Environment Forecast Center, he was the logical choice for the job, and upon his retirement in 1964 the Olsons returned to Boulder.

His subsequent research and publications in the field of solar-terrestrial relationships led Dr. Roberts to choose him as a partner in the NCAR project initiated last September to follow up research begun in 1956 on the relationship between auroral storms and atmospheric circulation at 30,000 feet.

"Dr. Roberts took a ten-year break away from it," explains Olson. "He was the moving force behind the founding of NCAR, and is now the head of the University Corporation for Atmospheric Research, which operates it. Despite his administrative duties, he was able to spend a part of the summer of 1965 working on it. Now he puts in one research day a week on this project. It took two or three months to get people trained to respect his research day and let him alone. One day I got there before he did and found Senator Allott waiting for him."

The significance of the possible aurora-trough link lies in the fact that trough development is one of the most important influences on the North American continent's weather. About a third of the Gulf of Alaska troughs come into the central United States, and those which are preceded by an aurora penetrate about 200 miles farther south over the continent, bringing colder weather with them. Although it is clear that not all large troughs are triggered by aurorae, and not all aurorae are followed by the development of troughs, the probability of trough deepening seems to be approximately doubled by the occurrence of a magnetic storm. Moreover, the usual time lag between magnetic storm and maximum through deepening is about eight days. Better understanding of the aurora-trough relationship could eventually result in improved weather forecasting for the North American continent.

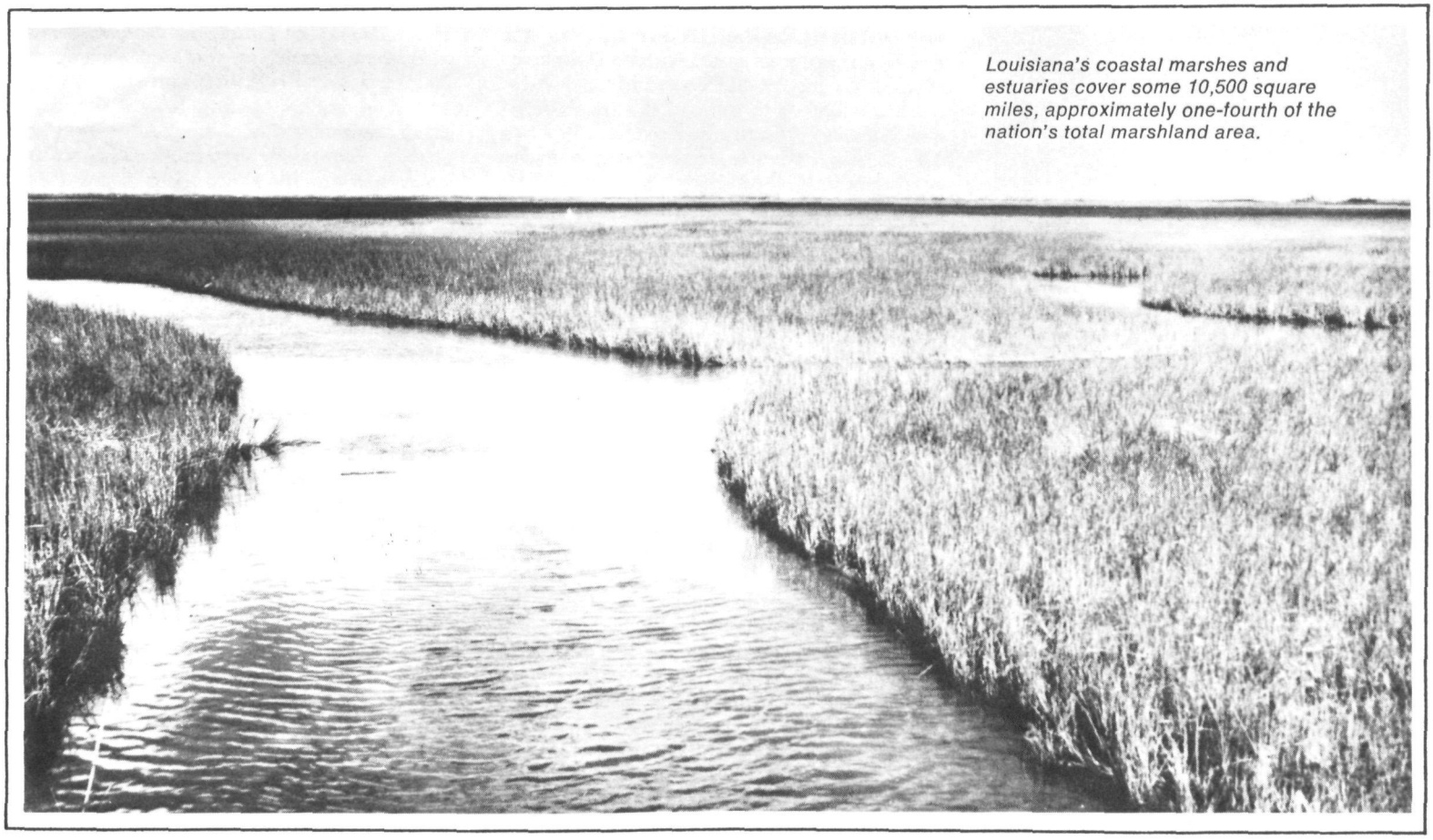
But Olson is already looking beyond this project. "My progression has been from geology, to meteorology, to geography, and in the last ten years, astrogeophysics. It's a little bit esoteric for somebody interested in the earth's environment. I've been concerned about the environment for many years, but more caught up in it the last year or two. Earth Day gave me a shot in the arm."

Never slow to translate thoughts into action, he has become active in Boulder's Eco-Center and in PLAN-Boulder County, an environmentalist political action group.

"I have some ideas," he concludes, "which are hard to express fully—to see us save the environment without losing the people. I really don't think the population growth in this country is the problem, so much as the wasteful way we go about things. Many tasks now being done poorly could be done more efficiently, and save money, time, and the environment." □

Roger Olson and Dr. Walter Orr Roberts of NCAR at work.

TREASURES OF BARATARIA BAY



Louisiana's coastal marshes and estuaries cover some 10,500 square miles, approximately one-fourth of the nation's total marshland area.

BY JOLINE FAXON

The natural riches of a famous pirate's hideout are explored in Louisiana State's Sea Grant program.

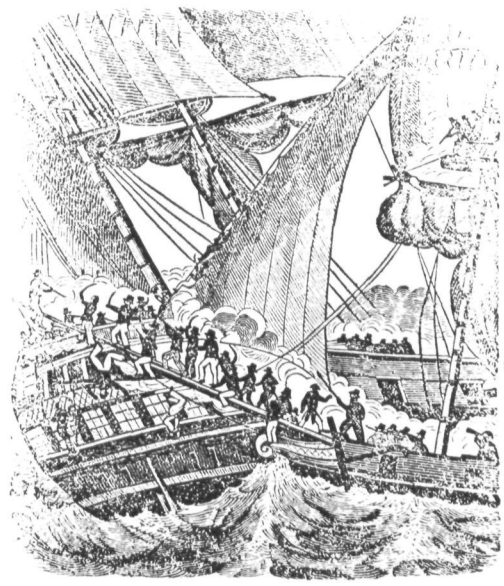
Louisiana's fabled Barataria Bay, once the hideout of pirate Jean Lafitte, today is the site of a new kind of treasure hunt, one that holds more economic promise than any cache of pirate's gold.

In the early 19th century, Lafitte used the sprawling marshlands of Barataria as a base of operations to plunder ships in the Gulf of Mexico. And, from his pirate headquarters on Grand Terre Island in the bay, Lafitte is said to have launched equally devastating forays into the highest social circles of old New Orleans.

If the slippery pirate could revisit his island haunts now, he would see a new kind of boat plying the waters of Barataria, its crew armed not with cutlasses but with scientific instruments, its mission quite the opposite of plunder.

For Barataria Bay, long a major center of Louisiana's shrimping and fishing industries, is the focal point of an intensive ecological study by Louisiana State University scientists working under NOAA's National Sea Grant Program to discover the real treasure of Barataria's warm brackish waters. What they find will contribute to the development of a far-reaching coastal resources management program to benefit Louisiana and the nation.

Joline Faxon is on the staff of Louisiana State University's Office of Media Services.



Jean Lafitte's pirates capture a prize.

Barataria Bay is one of the many bays and inlets along Louisiana's uneven coastline. The marshes and estuaries of coastal Louisiana cover some 10,500 square miles, constituting about one-fourth of the nation's total marsh area. Among the states, only Alaska and Florida have longer tidal shorelines.

The subjects of the Barataria ecology study read like ingredients for a giant Louisiana gumbo: shrimp, oysters, croaker, redfish, blue crab. Indeed, more efficient production and harvesting of these delectable coastal inhabitants is one of the ultimate goals of the Barataria project.

Under the initial Sea Grant funding, the Barataria Bay project concentrated on the potential of the bay's estuarine area for shrimp mariculture. Research on the life cycle of the shrimp within the estuarine environment continues to be an important part of the project, which last year was broadened to include all animal and plant life in the bay area.

Now in its fourth year at LSU, the Sea Grant program is part of the Center for Wetland Resources, created by the university in 1970 as a focal point for research and instruction in marine sciences and the coastal environment. The Center also encompasses efforts of LSU's internationally known Coastal Studies Institute and the Department of Marine Sciences.

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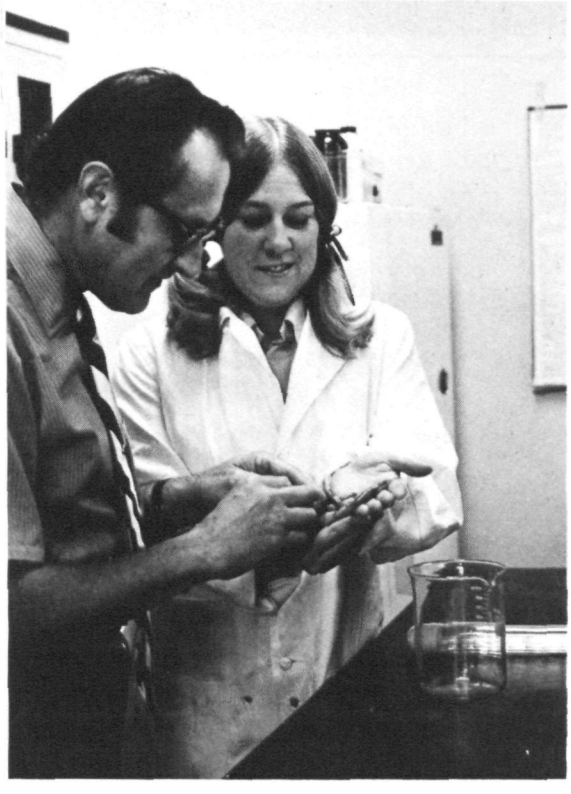


(Top) LSU field team takes bottom core samples aboard a research vessel. (Bottom) Professor Samuel P. Meyers of the LSU food science department and a graduate student examine a shrimp.

With its NOAA grant in September 1971, LSU attained Institutional Sea Grant status in the national program. Director of the Barataria project is Dr. William G. Smith, a marine scientist with the Coastal Studies Institute. For its field research expeditions, the Sea Grant program leases a camp at Chenier Camanada, just west of Grand Isle.

In attempting to unravel the structure of the Barataria estuarine environment, the Sea Grant scientists are looking at the entire marine-related food chain, beginning with the primary producers of the bay, the basic plants that take sunlight and convert it into plant food. In Barataria this process begins with *Spartina*, a species of marsh grass whose decomposing detritus forms the basis of the estuarine food chain. Other primary food producers include certain algae and phytoplankton.

The researchers are following the energy route of the food chain, beginning with the detritus and flowing upward, moving from the smallest creature to the higher forms of life in the bay. A network of interrelated studies make up the overall Barataria project, drawing upon the talents of many LSU scientists.

The monumental task of correlating the data collected in these individual research projects is a vital part of the program. Results of all the studies will be incorporated into a mathematical model, which is now being developed for the entire estuarine ecology system of Barataria Bay.

Using a hybrid (digital and analog) computer, Dr. Bert Wilkins Jr. and Dr. Ralph W. Pike, associate professors of chemical engineering, are preparing the ecosystem model, simulating the biological energy flow from shore to water, and the interplay of plant and animal life in the food chain.

This interplay of plant and animal life in Barataria Bay starts with the marsh grasses. Here, at the very basis of the food chain, occurs the microbiological process by which the grass is converted into high-protein detritus. Dr. Samuel Meyers of LSU's Department of Food Science and Technology is working toward a better understanding of this process. In particular, he is studying the fungi, especially the yeasts, that occur in association with the estuarine marsh grass.

A general study of the larval organisms that enter and leave the Barataria estuary by way of Caminada Pass is being carried out by Dr. Frank Truesdale, assistant professor of fisheries. A large variety of fish and crab larvae feed upon the detritus and phytoplankton of the estuary, and the larvae themselves are, in turn, a food supply for some of the higher forms of life.

In addition to his larval studies, Dr. Truesdale is also attempting to calculate the number, size, and kinds of fish entering and leaving the tidal pass. He is one of many LSU scientists who periodically traverse the bay's waters, gathering larvae specimens or netting fish to be studied.

A veteran LSU zoology professor, Dr. Harry Bennett, is collecting data on the wide variety of smaller marine animals which inhabit the estuarine waters, including the smaller crustaceans, bottom organisms, and marine creatures no larger than a grain of rice. Dr. Bennett, a recognized specialist on the marine fauna of the gulf coast area, was one of the authors of the proposal that led to LSU's first Sea Grant.

Based originally on studies of shrimp, the Barataria Bay project continues to concentrate on studies looking toward improved production of this commercially important species. After hatching in the sea, shrimp enter the Barataria Bay estuary in post-larval form, where they feed on the abundant food in the warm estuary waters. Here, they grow to commercial size in about two months.

In this area the commercial shrimping season for the brown shrimp (*Penaeus aztecus*) begins in May, and for the white shrimp (*P. setiferus*) in August.

Among the shrimp studies in progress is one directed by Dr. Harold Loesch, professor of marine sciences. Working about five miles inland from the Barataria shoreline, he checks the number, size, and sex ratio of shrimp in the estuarine area.

Shrimp nutrition is the basis of several of the other Barataria research projects. Dr. Clara Ho of Coastal Studies is investigating the inorganic nutrients, nitrate, phosphate, and silicate, which occur naturally in the estuarine water. These nutrients influence the production of phytoplankton and algae in the waters and sediments of the estuary; the phytoplankton and algae form of the shrimp's diet.

Dr. Ho also has done research on the amino acid content of the detritus material in the estuarine waters and sediments, and this investigation has been extended to include the effects of amino acids in experimental feeding of shrimp.

Lipid materials, or fats, present in the suspended matter in Barataria waters are under study by Dr. Scott Allen, professor and head of the LSU biochemistry department. He is concerned with the role these fatty materials play in the diet of shrimp.

Other individual studies within the ecosystem project deal with food conversion by shrimp of both the natural detritus diet and artificial feeding; the conversion by the shrimp's digestive system of chitin, a major component of the shells of crustaceans; and the algae attached to the marsh grass.

One result of the integrated Barataria Bay project is nearing completion and has already begun functioning—a mathematical model of shrimp production. With information fed in by the researchers in the bay, the developers of the overall Bay model have devised a shrimp model that coordinates all known information on post-larval shrimp in the Barataria coastal area. The economic implications are obvious: by providing precise data on shrimp growth and movements, the model can be used to predict the size and timing of the shrimp crop. The shrimp model can therefore be a valuable aid to the Louisiana Wild Life and Fisheries Commission in determining the best time to open shrimping seasons in the state's coastal bays. The Sea Grant program is cooperating closely with the Commission, which heretofore has relied

principally upon the personal experience and observations of its own experts in estimating the shrimp crop.

Other commercially important links in the Barataria Bay food chain include the croaker, redfish, and blue crab. All are under Sea Grant scrutiny, and a biogeographic history of the blue crab in the Barataria estuary was completed last fall. It will have important application in the production of soft shell crabs in the area.

The Louisiana gulf coast produces croaker and redfish in abundance, although Louisiana consumers, who have easy access to some of the world's most highly prized table fish, are not overly fond of the croaker. However, the croaker is a food fish in the eastern United States, and it is a major ingredient in commercial meal-mix used for fish food and other animal feeds.

The life and growth of the croaker and the redfish are being traced in Barataria by periodic sampling, counting and weighing. Stomach contents of the fish are also analyzed for clues to feeding habits and patterns. Researchers cover a series of stations from the sea line inland for about 25 miles, drawing most of their catches from the western side of the bay.

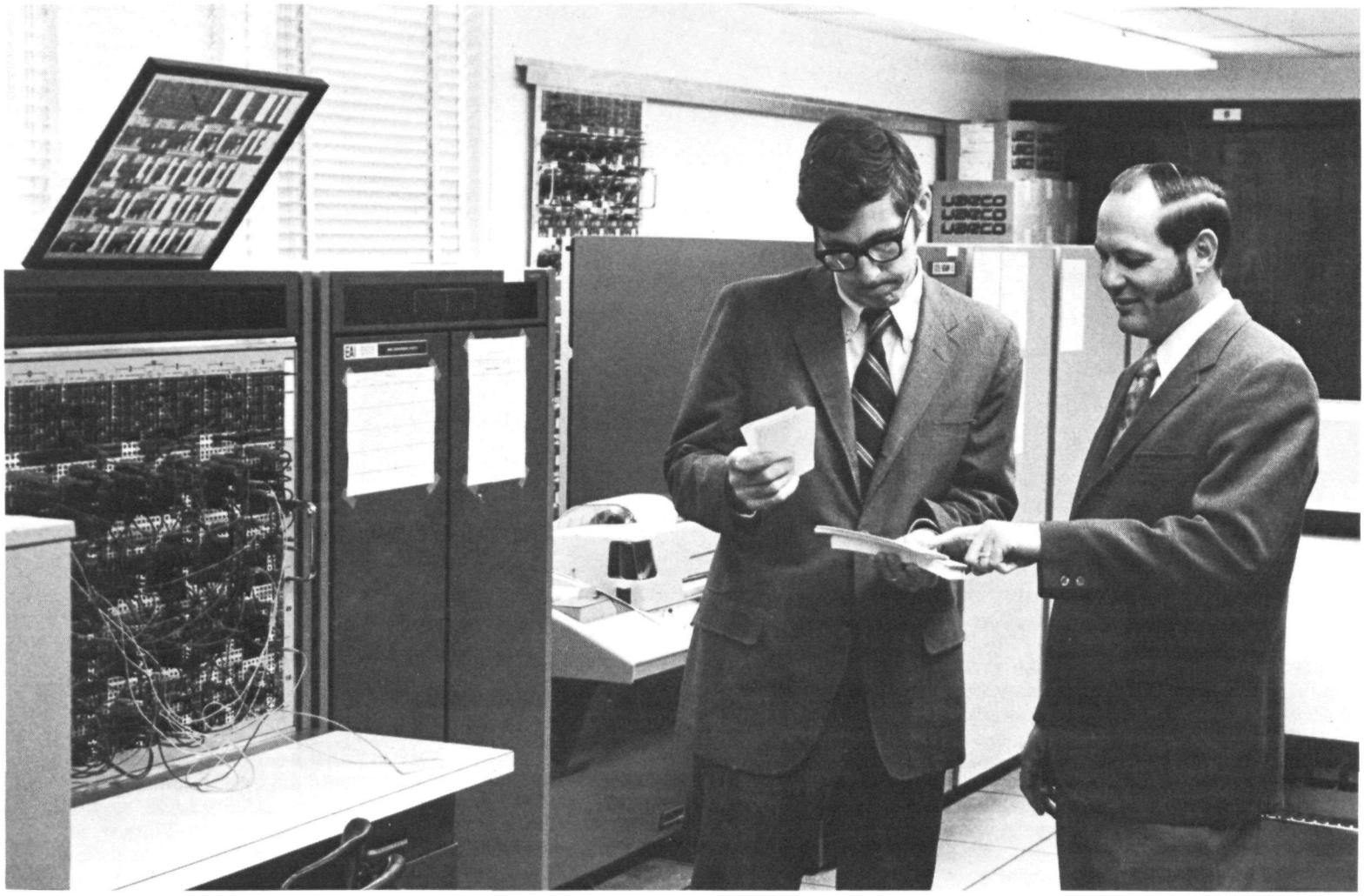
The comprehensive ecosystem model which is being worked out for Barataria Bay could be used to predict the production of commercially important shellfish and fish in addition to shrimp. From the standpoint of general coastal management, the model can be applied to determine the consequences of a variety of outside factors, such as the destruction by man of the vital marsh grass. For example, the computerized model could show how many pounds of the shrimp crop would be lost by destroying one acre of marshland.

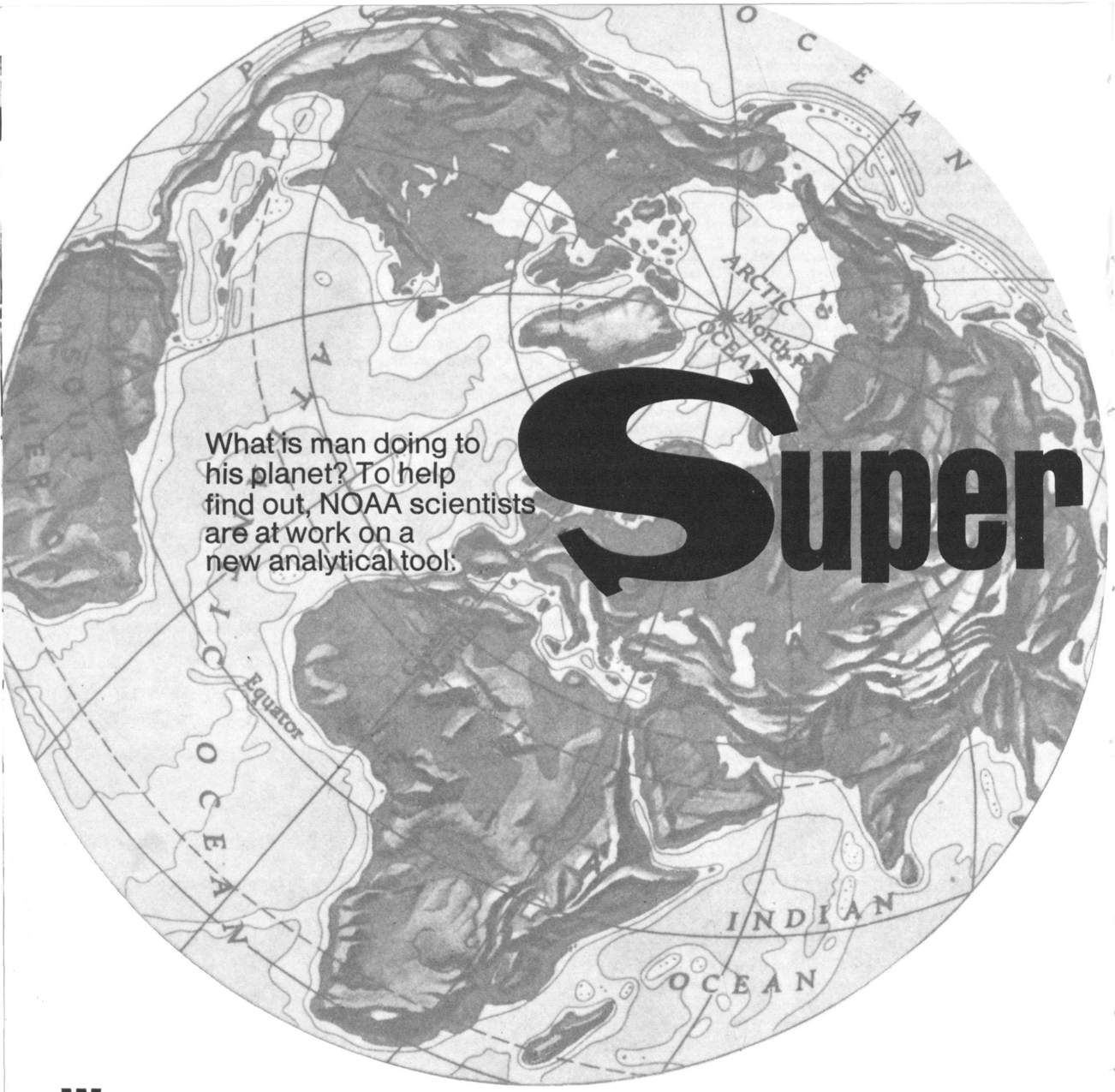
The Barataria ecosystem model will contain general information about the economic aspects of Louisiana's fishing and shrimping industries, including employment figures and other financial data. This part of the program is under Dr. Lamar B. Jones, associate professor of economics.

Biological and physical composition of the Barataria Bay waters will be structured for the mathematical model by Dr. John Day, an associate in the LSU Sea Grant Development Program.

The Barataria studies will play an important role in LSU's contribution to the national Sea Grant Program and to progress toward a balanced, productive program of management for the rich Louisiana coastal area. And, after serving the state of Louisiana as a land-grant institution for more than 110 years, the University is now striving—through research, education, and advisory services in marine resources—to achieve further national and international recognition as a Sea Grant College. □

(Above) Shrimp boats nestle close to the bank of a south Louisiana waterway. The state's coastal marshlands are the base of operations for both the shrimping and fishing industries. (Below) Dr. Bert Wilkins, Jr. (left) and and Dr. Ralph P. Pike, LSU associate professors of chemical engineering, discuss the mathematical model of Barataria Bay's ecosystem





What is man doing to his planet? To help find out, NOAA scientists are at work on a new analytical tool:

Super model

BY JOANN TEMPLE DENNETT

What will the earth be like to live on in another century?

Will steadily increasing pollution of our natural waters finally alter the heat balance of the world's oceans and cause sweeping climatic changes? Will carbon dioxide and other manmade pollutants so thoroughly foul our air that our great-grandchildren will have gas masks in every closet?

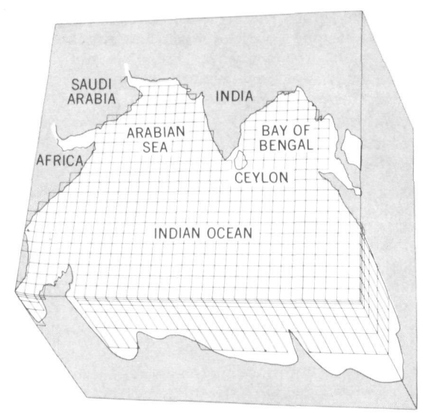
What are likely to be the major environmental problems of the future that should be faced today?

Scientists of the Environmental Research Laboratories are laying the groundwork to find some definitive answers to these questions by reproducing our global environment in a computer.

With the ultimate goal of accurate prediction of the general features of the world's environment at any point in the future, scientists at ERL's Geophysical Fluid Dynamics Laboratory in Princeton, New Jersey, headed by Dr. Joseph Smagorinsky, are combining mathematical models of the world's oceans and the atmosphere into an all-encompassing model of the earth's "fluid envelope."

This computer model is a structure of physical conditions and laws, stated mathematically, that describes the behavior of the oceans, the atmosphere, and their interactions. There must be an equation or set of equations and conditions for each significant factor in oceanic and atmospheric circulation and, most importantly, these mathematical equations must define the interrelationships of all these various factors.

(From left) Dr. Kirk Bryan, Dr. Syukuro Manabe, and Dr. Joseph Smagorinsky, GFDL Director. Dr. Manabe's atmospheric model and Dr. Bryan's ocean model have been successfully meshed into a preliminary model of the fluid envelope surrounding the earth. The joint air-sea climate model predicts such factors as heat flux, evaporation, precipitation, wind stress at the ocean surface, and sea-surface temperature.



The GFDL computer model has the potential of reproducing major features of the world's oceans, as is evidenced by a recent model of the Indian Ocean designed by Michael Cox. The first rough computer solution was obtained by separating the Indian Ocean into 120 boxes; oceanic conditions were then calculated for each of these four-degree squares at six separate depth levels from the surface to the sea floor. The computer solution reproduced all the known major features of the Indian Ocean's circulation which change with the seasons.

The basic mathematical model is a complex problem even for a computer. This illustration is given by GFDL's Dr. Kirk Bryan who, in cooperation with Michael D. Cox, developed the ocean component of the climate model:

"Imagine that the room you are in is filled with water to table-top height. Now, if you knew the exact amount of heating and cooling, precipitation, evaporation, and wind stress on the surface of this mini-ocean, you could use the laws of fluid mechanics to accurately predict how the fluid would move about in the room as it received energy from the sun. But even the largest computers in existence today do not have the capacity to predict the motions of a body of fluid of room-size dimension in minute detail, so they obviously cannot do this with a true ocean.

"Imagine, however, that the water in the room is contained in a series of boxes made of open grillwork stacked one on another and side by side throughout the room. A computer can easily handle such factors as average changes in velocity of flow, temperature, salinity, and heat flow from box to box or, in the case of the computer model, from 'sub-cell' to 'sub-cell' in a model ocean."

The sub-cells used in GFDL's ocean model are typically about 100 miles square and some 300 to 600 feet deep. This allows resolution of large-scale oceanic features, but does not grasp details near the coasts.

In its present stage, Bryan's numerical model takes into account the shore outline and bottom topography of the oceans as well as differences in temperature, salinity and density, and the growth and movements of sea ice. All of these affect the heat budget of the ocean—the heat energy coming into the ocean from the sun and that sent back into the atmosphere by evaporation, reradiation, and reflection. In addition to affecting the flow and structure of ocean currents, the heat balance of the atmosphere plays a prominent role in determining the climatic structure of the atmosphere. The oceans act as a global heat source and sink. In fact, oceanic absorption and redistribution of much of the solar energy reaching earth is the primary driving force of our weather. Says Bryan, who was awarded the 1970 Commerce Department Gold Medal for this work:

"Most of our knowledge about the global climate is qualitative in the sense that we cannot accurately predict what will happen to our climate if any important factors are changed. We know that the ocean stores heat in summer and releases it to the atmosphere in the winter. It also transports heat from tropical to polar regions, which moderates seasonal climatic extremes. The atmosphere also plays a role in heat transport. However, the factors governing the division of heat transport between the ocean and atmosphere are not yet known."

Despite simplifications and uncertainties, the GFDL computer model has the potential of reproducing major features of the world's oceans as is evidenced by a recent model of the Indian Ocean, which has unique current changes with different seasons of the year. Designed by Michael Cox, the model includes such factors as: the diffusion of heat by small-scale, transient disturbances in the ocean circulation; temperature; salinity; velocity; drag created by bottom characteristics; and wind stress at the surface.

The computer started with an assumption that temperature and salinity were horizontally uniform across a stacked array of "water boxes." This was essentially a "rigid lid" on the ocean surface and homogeneous layers of temperature and salinity at each depth level. A first rough solution was done on a large horizontal scale, calculating conditions in the ocean at 120 points marked off in four-degree squares of latitude and longitude, each more than 50,000 square miles of ocean surface. The first solution was refined by reducing the size of the water boxes to two-degree squares (increasing their

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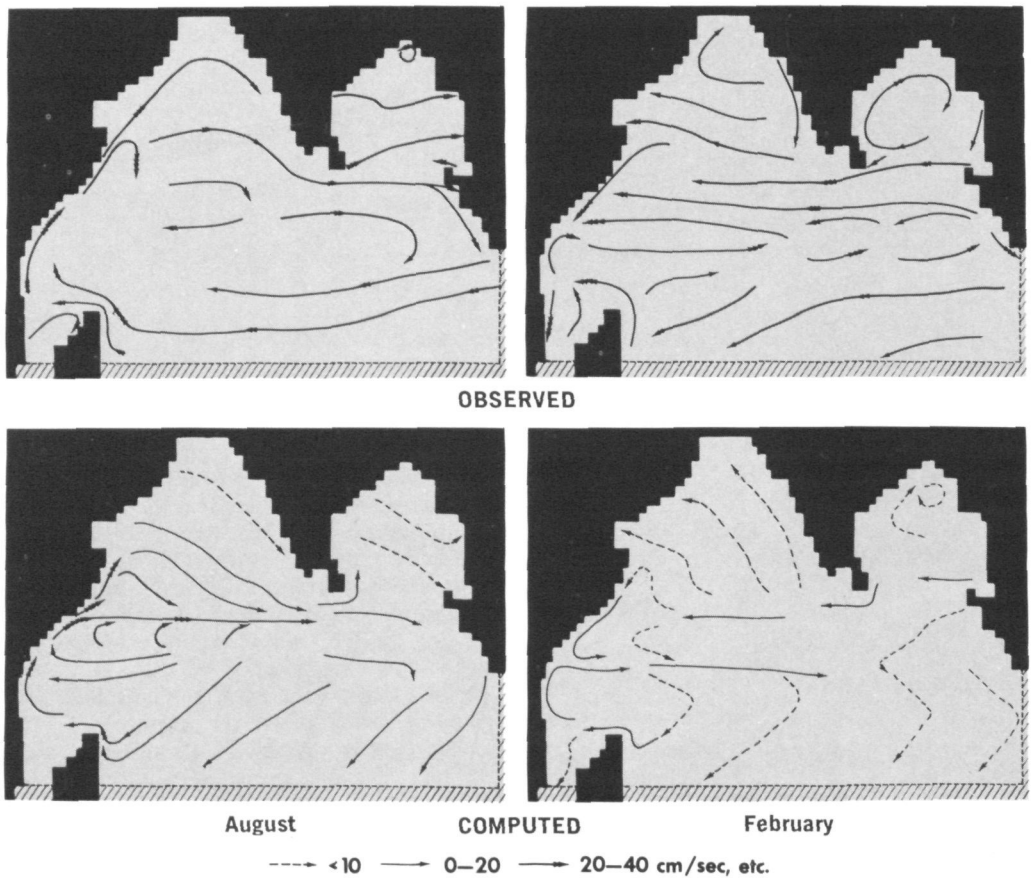


One checkpoint for the Indian Ocean model is the Somali Current off the east coast of Africa. This current reverses its direction, flowing northward in the summer and southward in the winter. (Left, top and bottom) The Somali Current typically flows north along the coast of east Africa in August. Although the computer-predicted flow of surface waters is far from exact, it does reproduce well the general northward direction of this distinctive current's summer behavior. (Right, top and bottom) By February, the Somali Current is reversed and flows southward. GFDL's model successfully predicted this shift of surface waters.

number four times) and running the computer again. Similarly, the second solution was further refined to a one-degree-square grid requiring calculation for almost 2,000 points. The computer produced an estimate of the circulation and changes in water density that compared well with actual seasonal cycles in the Indian Ocean.

The computer solution, obtained by integrating the model's mathematical equations through two centuries of time, reproduced all the known major features of the Indian Ocean's circulation which change with the seasons. For example, the computer prediction for an average August successfully showed a clockwise flow which corresponded to the actual surface circulation direction.

One checkpoint for the model is the Somali Current off the east coast of Africa. This current reverses its direction, flowing northward in the summer and southward in the winter. The seasonal changes in the Somali Current are predicted by the model although the actual current is too narrow and shallow to be completely pictured on the large-scale grid used. Thus, the scale of the computer-predicted seasonal changes is smaller than actual, but the vertical structure and total transport of water are given quite accurately by the model.

"The model's primary limitation is grid resolution," says Cox. "Using a smaller grid and higher speed computers, much more accurate simulations should be possible with the same model."

The International Indian Ocean Expedition of the early 1960's provided much of the actual ocean-condition data used both to establish beginning conditions in the model and to check the computer's results.

In addition to the Somali Current, a second checkpoint available in actual ocean data is highly variable salinity distribution in the Indian Ocean. Fresh water runoff from coastline and precipitation are excessive in the Bay of Bengal, while evaporation greatly exceeds precipitation in the Arabian Sea. The computer model handled this factor by realistically showing a decrease in salinity with depth west of Ceylon in the Arabian Sea and a salinity maximum under fresh surface water in the Bay of Bengal.

Oceanic models such as that of the Indian Ocean are now being combined with atmospheric models devised by other scientists in the Laboratory. Dr. Syujuro Manabe's model of the general circulation of the atmosphere and Bryan's ocean model have been successfully meshed into a preliminary model of the fluid envelope surrounding the earth.

The joint air-sea climate model—which handles ocean basins with irregular coastlines, bottom topography, and the effects of islands—predicts such factors as the heat flux, evaporation precipitation, wind stress at the ocean surface, and sea-surface temperature. In the joint model, calculations are made at nine levels in the atmosphere and five depths in the oceans. The vertical spacing of the layers was selected to give maximum resolution at the sea-air interface. Density of the water is calculated for each layer. Boundary or beginning conditions are given the computer for velocity, temperature, and salinity, and a bottom drag is specified. Surface wind stress is a variable boundary condition. Because differences in water density largely determine the vertical motion or mixing of water, this is a calculated variable in the model.

In addition to considering the global water and heat balances, the model includes a method for calculating the growth and movement of sea ice. Ice is an important factor at high latitudes because it forms an insulating shield between the air and the ocean, accentuating any other tendency of the environment to become colder. Clouds and water vapor, both of which affect radiation and consequently the heat budget, were held fixed in this preliminary calculation.

More detailed future ocean models, run in faster computers, will be able to play an important role in planning and executing major oceanographic expeditions. An advance survey of the body of water in question could be made by gathering surface and boundary data for input to a numerical model. The solution yielded by the model could then act as a guideline in planning a more complete observational program.

Further refinement of the models will also depend on new studies of the variability of ocean currents now being planned. These will consist of detailed measurements made by a dense array of moored buoys under the auspices of NOAA's National Data Buoy Center. Such measurements will permit direct checks on the role of small-scale motions less than the size of the numerical model grid and suggest ways to include them in the model.

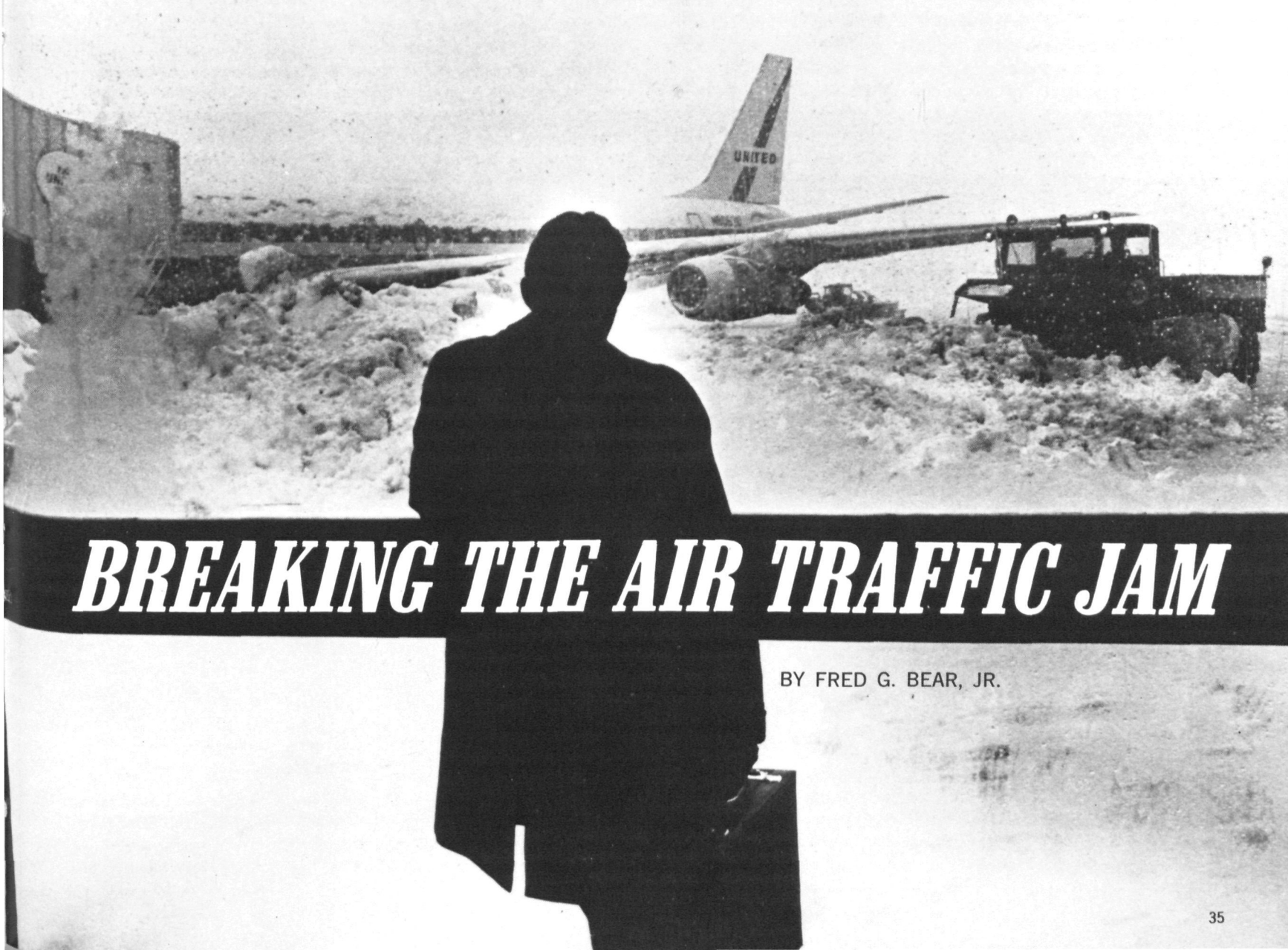
Problems of pollution of the oceans and large inland water bodies could also be studied with these models if the sources of pollution are known. Says Bryan:

"These days, we hear dire predictions of environmental disaster. So many effects of human activity have been suggested as detrimental to our planet that it is hard to assess their relative importance. GFDL's goal is to make models that will be a quantitive tool to test all these factors and to discriminate between those effects on the environment which are of lesser importance and those which might require urgent attention." □

Four National Weather Service men help FAA reduce flight delays.

BREAKING THE AIR TRAFFIC JAM

BY FRED G. BEAR, JR.



PLANES ARE ARRIVING on schedule more often these days, and part of the credit is due to four National Weather Service meteorologists who share an unusual assignment.

Like highways on the ground, the airlanes over the United States have a limit on how much traffic they can accommodate safely. But in the superhighways of the air, traffic problems assume larger dimensions. While a tie-up on a surface road can tangle traffic for many miles, the effects of a runway shutdown at a single major United States airport are felt from coast to coast.

Without a national focal point for controlling the flow of air traffic, planes could circle for hours, waiting to land at an airport that is operating at reduced capacity. Or storms along a major airway could create a bottleneck, with too many pilots seeking to fly the same route around them. In 1969, air traffic delays were estimated to total 24 million minutes, costing the airlines 158 million dollars.

To prevent such traffic bottlenecks, the Federal Aviation Administration inaugurated a Central Flow Control Facility at its Washington, D.C., headquarters in January 1971. The facility has available current information on the operational status of all Air Traffic Control (ATC) systems, on the airspace reserved for military use, on expected air traffic, and on weather across the nation. Such information is vital to the job of ensuring that air traffic does not exceed the system's capacity in any area.

When available airspace reaches the saturation point, traffic is rerouted. When long delays are predicted at a major airport, precise departure times are assigned to aircraft flying to that terminal.

continued

Fred Bear is a National Weather Service meteorologist assigned to the Federal Aviation Administration's Central Flow Control Facility in Washington, D.C.

Because weather is one of the most important factors in determining the capacity of the nation's airways, four National Weather Service meteorologists are assigned to the Central Flow Control Facility—Otho ("Tex") Eakin, John Blasic, Henry Wise, and myself. Working in shifts, the staff provides meteorological service to the facility from 7 a.m. to 11 p.m., seven days a week.

Each day, the meteorologist on duty starts his shift by assembling weather data received by facsimile and teletypewriter, familiarizing himself with the weather conditions over the entire country, and then conducting the morning briefing for the facility's staff. Using direct conference lines and a speaker system, several Air Route Traffic Control Centers are briefed at the same time. After a "broadbrush" look at the weather, questions from individual centers concerning more specific elements are answered.

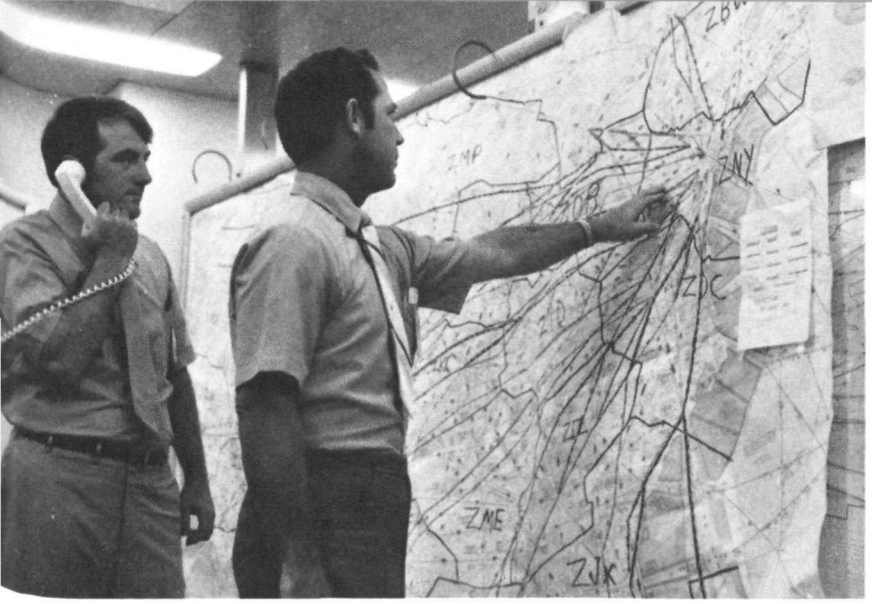
The New York area, for example, has a special weather-related problem. Because of the high density of traffic funneling into the relatively small airspace controlled by the New York Center, adverse weather conditions may make it necessary to put a limit or quota on traffic to be released to New York from other airports. A decision on such a restriction must be made early in the day to have any effect on West Coast departures. Since the heaviest flow of traffic into the New York area comes late in the afternoon, a forecast for this later period is most important. If weather conditions are predicted to improve materially by late afternoon, advance flow control restrictions usually are not put into effect.

Weathermen in the Central Flow Control Facility are called upon for critical decisions as to how large-scale weather systems will affect a single airport. On the morning of February 22, 1971, an intense storm was centered over northeastern Missouri. Strong winds around the storm were piling up snow drifts several feet high in the west central Plains, while freezing rain over a large area east of the storm made driving extremely hazardous. Another measure of the intensity of the storm was the fact that its counter-clockwise, or cyclonic circulation extended from the surface to well above 20 thousand feet. Low clouds and poor visibility slowed air traffic over all of the northeastern United States. Over the Southeast, severe thunderstorms and tornadoes again threatened, after the disastrous Mississippi tornadoes of the previous day.

At about 8 a.m. that day, the Central Flow Control Facility conferred with the several Air Route Traffic Control Centers throughout the country, in preparation for the routine morning report. Center after center reported delays caused by the impact of bad weather on the system. As the situation developed, the most crucial factor turned out to be the direction of the surface wind at one airport—O'Hare International in Chicago.

O'Hare has a dual-runway system—two runways side by side, which can be used at the same time. But with certain wind directions, and low clouds and visibilities, only one runway can be used, and the capacity of the airport is more than cut in half. Instead of the giant airliners arriving and landing at the rate of 55 per hour, they suddenly are restricted to landing at the rate of 20 to 25 per

Personnel in the FAA's Central Flow Control Facility confer by telephone with Air Route Traffic Control Centers across the nation to ensure that traffic does not exceed the system's capacity.



FAA flow controllers refer to chart before selecting a preferred route.

National Weather Service meteorologist Fred Bear checks late weather reports.

hour. Aircraft arriving from different parts of the country become stacked up in holding patterns, and delays mount. The saturation point for safe separation of aircraft quickly arrives, and eventually, if something is not done, the situation becomes chaotic.

Early in his shift, the operations officer at Central Flow recognized the potentials for a severe dislocation of the system. Then the flow controller at the Chicago center reported one-runway operations, and asked for relief. Central Flow's decision on what action to take depended on whether or not the wind at O'Hare airport would shift from northeast to southeast or south in the next few hours. The operations officer turned to the National Weather Service meteorologist working with him and asked: "What about it?"

The situation facing the weather forecaster did not present a clear-cut solution. Because of the intensity and depth of the storm, it was slow-moving, and could hardly pass O'Hare in time to give relief. There was also a warm front stretching eastward from the storm and south of O'Hare, which had shown little inclination to move in the past few hours. However, this type of front is notoriously erratic in its movement, and if the front did pass north of O'Hare, the wind would shift to southerly. After considerable agonizing study of the weather maps, the decision came back: "No wind shift for several hours."

Immediately after receiving this forecast, the operations officer sent out an advisory to all centers and all airlines, requesting that aircraft be held on the ground rather than released to flood the Chicago center airspace. Throughout the morning, details were thrashed out with the individual centers. As a result, only a manageable number of aircraft entered O'Hare's airspace during the morning to hold and wait for their turn to land. Later in the afternoon, the wind did shift at O'Hare, dual-runway operations resumed, and the situation gradually came back to normal.

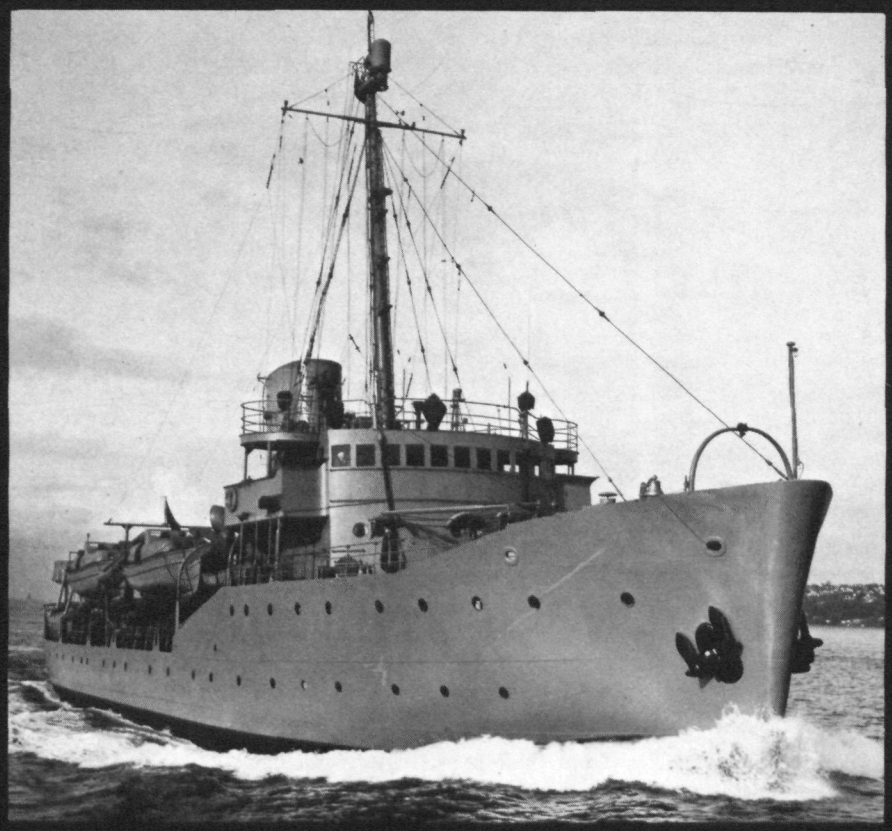
Throughout the year, though primarily from April through October, the big concern of the center's weathermen is thunderstorms. Will they occur? Where? More important, will they build up to heights of 35 thousand feet or higher, and form into lines? An individual thunderstorm may build to well above 35 thousand feet, and the airlines will deviate a short distance around the thunderstorm with no net delay and little effect on air traffic control. (An important exception to this is the New York center area, where traffic density is so high.) If thunderstorms form in fairly long lines, however, they can be a problem anywhere in the country. Now aircraft divert from their previously assigned airspace. The delays occasioned by diverting tend to snowball, as more and more aircraft are competing for the same space. In such a situation, it can become difficult for the controller to maintain adequate aircraft separation.

The meteorologist on duty in the facility is constantly scanning surface reports and radar summaries for important changes and clues to future developments. If he comes across any information which might be of value to an individual center, he immediately calls up that center and passes on the information. Radar reports are plotted on a large map of the United States, as are severe thunderstorm and tornado watches issued by the National Severe Storms Forecast Center of the National Weather Service in Kansas City, to give the facility's personnel a graphic and immediate picture of the situation.

On one occasion recently, the radar reports over the central part of the country showed not one, but several lines of thunderstorms, which were building and threatening to form into one very long line. A tornado watch had been issued by the Weather Service for the central Plains area. The Air Route Traffic Control Center at Kansas City was partially crippled because its auxiliary power source was not operating. If the strong gusty winds of even one severe thunderstorm blew down power lines and commercial power failed, most of its radar surveillance and communication capabilities would be wiped out, and all aircraft in the center area would be on their own, with consequent air traffic separation problems.

The Central Flow Control Facility decided to recommend rerouting all commercial flights around the Kansas City center area while the threat of severe weather continued. Conference calls were made to all centers, followed by an advisory on teletypewriter to the centers and all airlines. Once again, a potentially disastrous situation was averted.

In case of a catastrophic disruption of the entire air traffic control system, Central Flow is prepared to take over the direction of all operations. Its main purpose, however, is to minimize aircraft delays by ensuring the most efficient use of airspace. To attain this goal, new methods of metering and rerouting traffic are constantly being developed. A recent summary of the average number of delays throughout the Air Traffic Control system, showed a steady downward trend in the number of delays since the facility was instituted. Part of this improvement can certainly be ascribed to the National Weather Service weathermen. □



Requiem for the Pathfinder

1942—1971

The NOAA Ship PATHFINDER, perhaps the most bombed non-combat vessel of World War II, has been retired. The famous hydrographic survey craft, "sunk" six times by Tokyo Rose, underwent some 50 bombing attacks, shot down two Japanese aircraft, and survived a direct kamikaze plane hit. She ended her wartime service surveying Japan's home islands for the allied occupation forces.

The Seattle-based ship is the oldest of 15 oceangoing vessels of the National Ocean Survey which conducts surveys on the high seas and in America's coastal waters and estuaries. The sleek 29-year-old, 229-foot, 2000-ton white ship carried a complement of 84 officers and men.

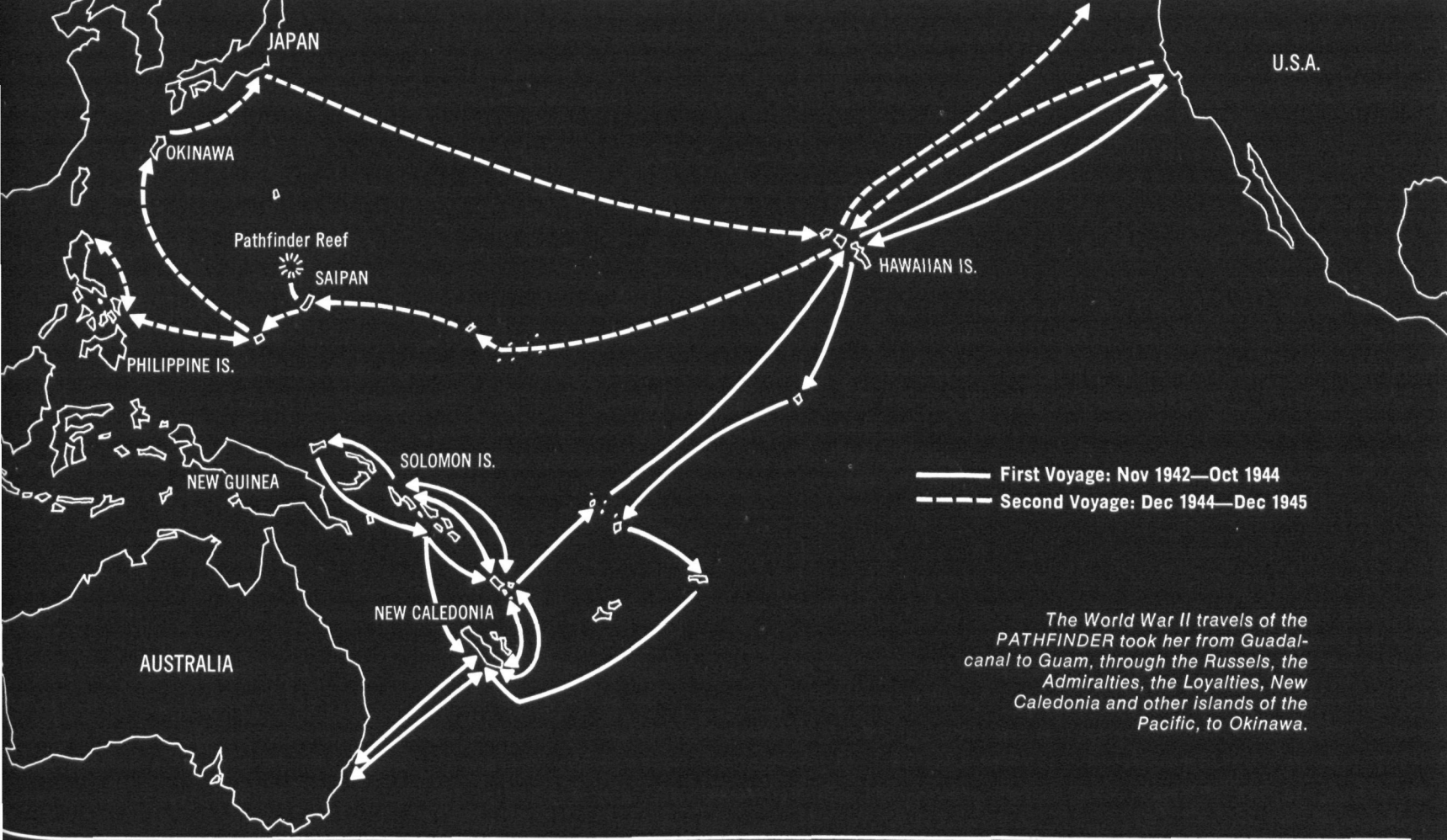
Since the war, she's been making oceanic and hydrographic surveys in and about the Pacific Northwest and Alaska. There are still good years left in her, but the need for economy has caused her to be retired to a dock in Seattle, Washington, where she'll remain in an inactive status—a locked, dead ship with no personnel living aboard.

To the hundreds of men who served aboard the ship, the PATHFINDER was "a gallant lady," an unusually lucky ship which on several occasions narrowly escaped the fate meted out to her by Japan's wartime radio broadcaster, Tokyo Rose. When the kamikaze struck her off Okinawa on May 6, 1945, the 500-pound bomb aboard the plane failed to explode, and the ship escaped destruction. One crew member was killed, and the ship's capstan demolished. Fire broke out on the afterdeck, but was brought under control in an hour.

The PATHFINDER was built in 1942 at Lake Washington Shipyards in Houghton, Washington, in accordance with plans and specifications drawn up by the Coast and Geodetic Survey, predecessor of the National Ocean Survey. But immediately after her commissioning—at which Eleanor Roosevelt Boettiger, 14-year-old granddaughter of President Roosevelt—was the sponsor, she was turned over to the Navy and staffed by commissioned officers of the Navy and the Coast and Geodetic Survey.

Throughout the war, PATHFINDER led a charmed life. On April 7, 1943, she shot down two attacking planes at Guadalcanal. On March 13,

Eleanor Roosevelt Boettiger, granddaughter of President Roosevelt, was sponsor at the PATHFINDER's commissioning in 1942.



The World War II travels of the PATHFINDER took her from Guadalcanal to Guam, through the Russels, the Admiralties, the Loyalties, New Caledonia and other islands of the Pacific, to Okinawa.

1945, while liberating the village of Casiguran on Luzon Island in the Philippines, she was again attacked by several Japanese planes, but escaped unscathed.

It was off Okinawa that she underwent most of her bombing attacks. From then until the end of hostilities, the PATHFINDER called her officers and crew to battle stations 170 times.

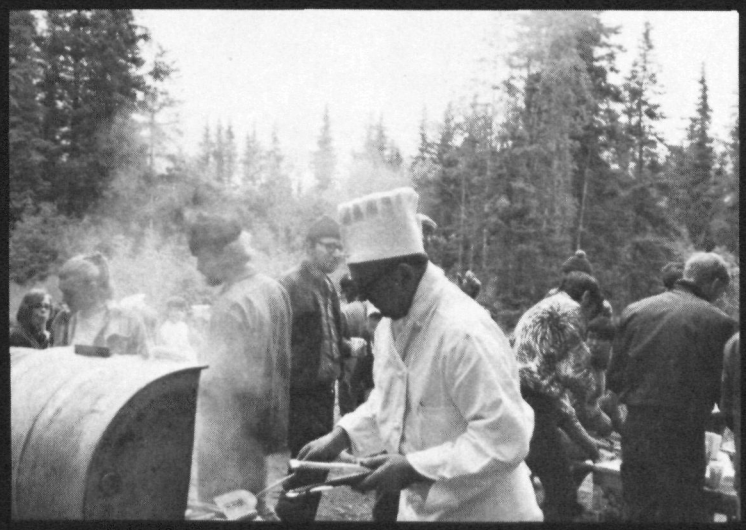
The work she carried on was varied. Traveling to an isolated reef, an uncharted harbor, a lonely stretch of enemy-held coastline, the PATHFINDER blazed trails for other American vessels to follow. Late in 1944, she discovered and charted a reef about 350 miles northwest of Guam which now bears her name. The lightly armed survey ship was then anchored closer to the Japanese mainland than any other American ship had been since the war began.

The PATHFINDER's surveys took her from Guadalcanal to Guam, through the Russells, the Admiralties, the Loyalties, New Caledonia and other islands of the Pacific, to the Philippines and then to Okinawa. On several occasions, notably at Bougainville, Treasure Island, Green Island, Emirau, and Guam, advance parties went ashore into Japanese territory to work in close cooperation with American and Australian amphibious units in laying out harbor charts and surveying inland channels.

The PATHFINDER made two voyages in the Asiatic-Pacific War Theatre as a Navy survey vessel. The first, under the command of Captain Bascom H. Thomas, USNR, the PATHFINDER's first skipper, lasted from September 1, 1942, to October 21, 1944. Her second wartime cruise, this time under the command of Cdr. Francis L. DuBois, USNR, extended from December 18, 1944, to December 24, 1945.

For her excellent work in helping to survey the road to Tokyo, the PATHFINDER received the written commendations of Admirals Nimitz, Kinkaid, and Halsey and two campaign or battle stars for taking part in two major amphibious operations: the Consolidation of Southern British Solomons, April 7 to June 1943, and the Assault and Occupation of Okinawa Gunto, January 5 to June 30, 1945.

In August 1946, she was returned to the Coast and Geodetic Survey.



PATHFINDER crew members prepare a barbecue for children of the Alaska Christian Home.

Since then, she has been a hard-working ship, averaging 10,000 to 15,000 nautical miles each year in deep-sea hydrography in addition to hydrographic development of coastal areas off the Hawaiian Islands, the Pacific coast, and Alaska.

The PATHFINDER was well known to Alaskans, especially to the boys and girls of an orphan home at Homer, an isolated community of less than 1000 people at the entrance to Cook Inlet. Since 1965 the PATHFINDER has served as its "foster mother." Twice each year, around the Fourth of July and in September, the ship has played host to the children of the Alaska Christian Home and has donated fresh fruit, candy, toys, and clothing.

The PATHFINDER won't be going back there any more.

A 50-inch snowstorm of 84 years ago crippled eastern cities, took 400 lives and remains a landmark in weather annals

The BLIZZARD of '88

BY PATRICK HUGHES

"The snow fell fast and was caught by the wild winds and hurled everywhere . . . (it) came with such force into the eyes of the pedestrian as to blind him; melting . . . (it) would remain frozen fast to the eye, so that it was his constant work to protect his sight. The snow would follow the breath . . . into the lungs and . . . fill them with water, nearly choking him, if not quite doing the work of strangulation."

This is an eyewitness account of the blizzard of 1888 which affected one quarter of the country's population and isolated a dozen of its largest cities. It literally buried hundreds of towns and villages from Maine to Maryland.

The blizzard cut off and immobilized Washington, D.C., Philadelphia, New York City, and Boston. Snowfall averaged 40 to 50 inches over southeastern New York State and southern New England, with drifts to 30 and 40 feet. In Middletown, New York, snowdrifts were reported to have covered houses three stories high. The townspeople had to tunnel through the snow like miners, even shoring up the passageways with timber. For two days, frequent gale-force to near-hurricane winds accompanied below-freezing temperatures which ranged from near zero to the low twenties over much of the area.

Men, women, and children died in city streets, in country fields, and on ice-choked ships and boats. Over 400 died, 200 in New York City alone. Thousands more suffered everything from exhaustion to amputation of frostbitten limbs. Some wandered blindly into snowbanks and died quietly. Others became hysterical, shouting and cursing the wind, pounding the snow in tearful frustration.

The great storm buried trains all over the Northeast, marooning passengers for days and in some cases a week or more. Water froze solid in the washrooms, and there was usually little or no food. Card tables and seats were chopped up and burned in small stoves, but the drafty cars were still unbearably cold. Many left the trains to search for food or shelter; some perished.

The blizzard was a marine disaster from Chesapeake Bay through New England. Some 200 vessels were sunk, grounded, or wrecked and abandoned. At least 100 seamen died in the storm they called the "Great White Hurricane." Of 40 vessels in Philadelphia's harbor, only 13 escaped destruction or disabling damage, and at least 30 crew members perished.

In urban areas throughout the Northeast, telegraph, electric light, and telephone wires broke under the weight of wind, ice, and snow and poles snapped and toppled. Railroad and steamship stations were jammed with stranded travelers. Overnight, the most populous section of the United States was transformed into an arctic wasteland where nothing moved, an alien world of wind and white.

Although the blizzard blanketed an area from Maine through Maryland and from Buffalo to Pittsburgh, it was in New York City that the great storm became a legend.

Saturday, March 10, 1888, was a warm and sunny day in New York. Grass was growing, trees budding, and men talking of the upcoming baseball season.

It began to rain Sunday afternoon. By evening, the temperature had dropped, the wind was rising, and New York City's streets were coated with ice. The rain turned to

snow just after midnight on Monday, March 12. The snow continued all day, accompanied by northwest winds that reached nearly 50 miles per hour and temperatures that dropped to near 10 degrees.

Most New Yorkers first became aware of the storm when they tried to go to work Monday morning. It was a period of economic depression, and no one was likely to stay home if he could make it to his job. They started out by the thousands, but relatively few reached their destinations.

The wind had swept sidewalks clean on the south side of many streets, while snowdrifts 15 to 20 feet deep covered brownstone stoops on the north side and sometimes reached the second floor. The wind was cutting, the snow blinding. And the storm worsened between 7 and 9 a.m., when most working people were out on the streets.

Men were blown off their feet and forced to crawl on their hands and knees past exposed areas. Pedestrians were sprayed with flying glass from shattered windows, and occasionally felled by falling chimneys or flying signs. Cheeks cracked in the stinging wind and frostbitten noses swelled.

According to the *New York Times*, "the wind seemed to have a rotary motion as well as a terrible, direct propelling force . . . slinging the snow into doorways and packing it up against the doors . . . sifting it through window frames . . . piling it up in high drifts at street corners . . . twirling it into hard mounds around elevated railroad stations . . . as most New Yorkers had never seen before. For the first time in their lives they knew what a western blizzard was."

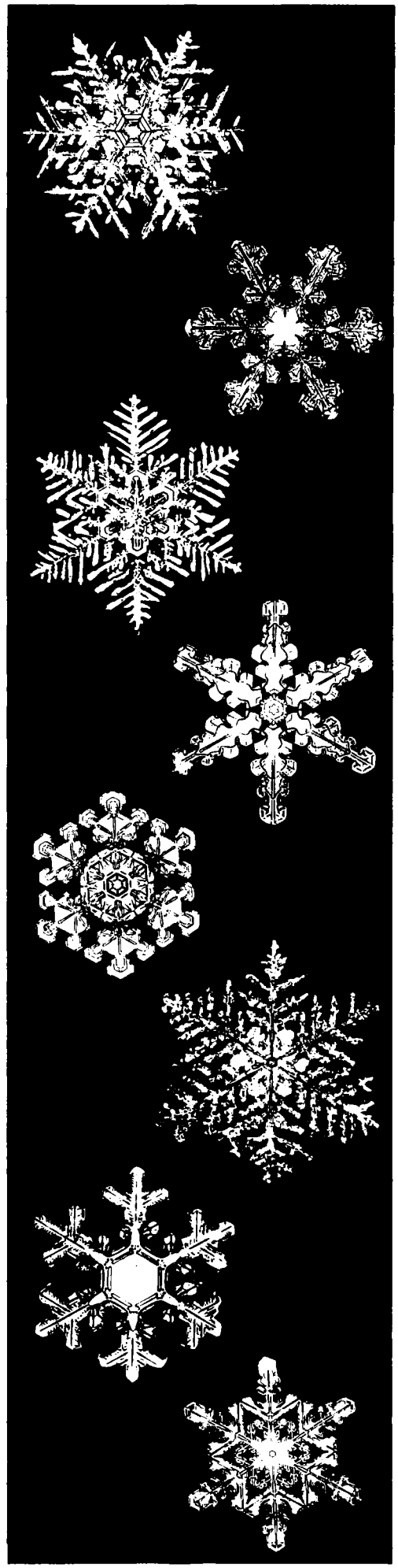
Horsedrawn streetcars were abandoned all over the city, and the steam-driven elevated railway trains were soon stalled. Hundreds of people jammed wind-whipped platforms waiting for trains that never came. Wealthier New Yorkers offered fabulous sums to cab and carriage and even wagon drivers to take them a few blocks or a few miles. Prices ranged as high as $40, but in most cases the conveyance bogged down and both passenger and driver were stranded. Sometimes the horse was rescued, sometimes abandoned.

Those who did manage to reach work generally found no one else there or nothing to do. They had to turn around and try to struggle home again or find a place to stay in the city.

Out on the streets, policemen were administering first aid to hundreds of people and rescuing drunks from certain death in snowdrifts. As the storm worsened, many had sought shelter in nearby saloons, which did a record business. While the loss of life was small, serious accidents were numerous, and many people were victims of exposure and overexertion.

In Brooklyn, more than 20 letter carriers were found unconscious in snowdrifts, and a great number of poor families had to be carried from icy, unheated hovels to the nearest police stations which, by noon, were filled to overflowing.

Near City Hall, a policeman found four girls lying unconscious on the sidewalk. He



dragged each of them across the street by their wrists to shelter in a nearby hotel.

Hotels, bars, private homes, and public buildings were jammed with people looking for shelter. Some eventually spent the night in jail on cots provided by the police, while a number of wealthy businessmen and bankers found themselves sharing quarters with skid row inhabitants; not a few had their pockets picked.

With trains, steamers, horsecars, and ferries halted, the city's only link to the outside world was the Brooklyn Bridge. Foolhardy pedestrians dragged themselves across hand over hand, clinging blindly to the railings as the biting wind cut them to the bone and blew their hats into the East River. The police eventually closed the bridge, for fear of someone being blown off or dying of exposure.

By nightfall New York City was an eerie, abandoned arctic landscape. Not a streetlight was on, and the streets were deserted. People stranded in the city knew nothing of those at home, and wives and children could only guess the fate of father or husband. Exaggerated rumors of deaths and disasters were everywhere, as the storm continued unabated.

Three hundred people spent Monday night in Grand Central Station and were still there Tuesday night. More than two dozen trains were stranded enroute to the city, with ten stalled in northern Manhattan alone.

The Albany Express was snowbound for 48 hours at Hastings-on-Hudson, north of the city. The passengers were so impressed by nature's interruption of their daily lives that they formed an association called "The Snow Birds," and resolved to meet annually on March 12 to commemorate the event.

Charles Palmer, who worked on Broadway, left Stonington, Conn., at 12:30 Monday, and two hours later he and 180 other passengers were stuck in an 18-foot drift. They stayed there for two days, except when compelled by hunger to send a foraging party to a nearby farmhouse. One of the volunteers was badly frostbitten and was thought to have suffered "permanent injury."

Among the passengers was a Mrs. Parker with a nurse and two small children. When her brother learned of her situation, he hired a tugboat and reached Sable Point, about 5½ miles from the train at about 10 a.m. Wednesday morning. It took him and his rescue party four more hours to plow through the snow to the train. Besides the four ladies and the babies on board, Mr. Palmer and one other gentleman were rescued. The other 170-odd souls were still stranded on Thursday and, according to Palmer, might be there much longer, as the railroad had made no efforts to send out a rescue party.

Back in the city, residents began clearing the sidewalks early Tuesday morning, after the snow tapered off to a light fall. The snow had packed down hard, and axes and picks were needed to break it up.

Most New Yorkers left for work Tuesday morning before the snow shovelers began

continued

(Top) The snow continued all day, accompanied by northwest winds of nearly 50 miles per hour. (Bottom) The wind swept sidewalks nearly clear on one side of the street and piled snowdrifts on the other.

working, burrowing through or climbing over drifts as big as a 60-ton locomotive. Broken windows, wrecked signs, torn awnings, and snowbound cars and wagons greeted them everywhere.

Sleighs, skis, and snowshoes became common sights on Fifth Avenue, Broadway, and other main thoroughfares, and the city looked more like Moscow than New York. One woman commented that it was strange to see sleighs sliding over snowbanks at the level of second story windows.

There was suffering in New York's East Side slums, where thousands of immigrants were crowded into the city's shabbiest tenements. Food was scarce and coal ran out; there was no milk for babies. Except for milk and dairy products, there was no real food shortage. Supplies were scarce only because they couldn't be delivered. East Side inhabitants lived from day to day, buying their coal by the pailful, their flour by the pound, their butter by the half pound, and their tea by the quarter pound. The stores they dealt with kept small stocks, which they replenished once a week. Monday was their usual purchasing day, after the weekend trade had cleaned them out. The blizzard made it impossible for the wholesale houses to deliver.

Many store owners raised prices. Coal went from 10 cents to 20 cents a pail and, according to the *Times*, "Eggs sold at 40 cents, wretched butter at 60 cents, the poorest beefsteak—called steak only by the most barefaced mendacity—for 30 cents a pound."

Paradoxically, the blizzard proved a financial blessing to the city's poor. Any man or boy able to lift a shovel could make at least double the normal laborer's wages. Street car companies, street cleaning agencies, and many private organizations were giving work to all comers at two dollars or more a day. The biggest bonanza of all was shoveling snow for private homeowners and shopkeepers. Many men made as much as ten dollars a day, and all were paid well above scale. The shoveling was still going on by Friday the 16th, and the end was not in sight.

It required thousands of men to clear the principal streets of snow and most of the laborers were recruited from the East Side. Facing removal of an estimated 20,000,000 cubic feet of snow, Superintendent Green of the Street Cleaning Department remarked that the city was fortunate the storm came in March, rather than December or January, when a freeze would have caused indefinite paralysis.

Ferries began making occasional runs to New Jersey Tuesday morning, and elevated trains started running sporadically a few hours later. Many people were injured during the day from falls on the wind-exposed, glazed pavements and by mid-afternoon, the police had shot some 20 horses that had broken legs.

On Thursday, March 15, with bright sunshine and rising temperatures, a thaw set in. Soon ponds, puddles, and small lakes appeared and many basements were flooded. The situation was particularly bad in Brooklyn, built on a series of hills and valleys and vulnerable to serious flooding.

People who had been snowbound in the suburbs or country towns began to arrive in the city by midweek and with each train came tales of higher snowdrifts. The highest reported was a 52-foot drift in the neighborhood of Gravesend, reported by a John McKane. Great damage was reported at Rockaway Beach, where new buildings under construction for the electric light company, part of a hotel, and numerous small buildings had been blown down.

Many casualties were discovered during the days following the storm. The body of a boy about 12 years old was found in the snow at Cypress and Fulton Avenues, East New York. Although not identified, it was thought to be that of a newsboy who had left the Howard House in Canarsie on Monday and not been heard from since.

An Irish coachman who had driven his carriage all day "Blizzard Monday" had died just after reaching home, and the little son of Baker Provst, who had started out on his daily delivery rounds on Monday, was missing and presumed dead.

An unknown man was dug out of a drift on Fulton street and died at the City Hospital without regaining consciousness.

Henry Henrihan, of Raritan Township in nearby New Jersey, left Milltown Monday morning to go home. He was "somewhat intoxicated" at the time and had not been heard from since. When the neighbors went to his home to tell Mrs. Henrihan, they found her dead in bed, a victim of cold and

hunger, and her children half-starved and frozen.

Samuel Randall, an 80-year-old Long Island farmer, went out to the barn to feed his horse and cattle on Monday night and lost his way coming back to the house. Two elderly women who had been nursing his sick wife went out in search of him and, after a half-hour found him nearly frozen to death. They tried to carry him into the house, but failed and had to leave him to save their own lives. No other help could be found before morning, when he was discovered dead.

The storm played havoc with New York's fleet of pilot boats and other shipping. Ice had to be cut constantly from the riggings; meanwhile, heavy waves sent spray over the vessels from one end to the other, and the ice formed again with incredible speed. The sails became so stiff they broke like glass. Many crews were forced to take to the ships' yawls and were caught by the gale winds. The lucky ones were carried up on the shore. One of the yawls, a 600-pounder, was blown over and over nearly 150 feet up on the beach.

The NIAGARA, arriving from Havana, reported that Sunday night her deck had been covered with knee-deep snow. At noon on Monday, a high wave carried away 40 feet of her railing on both sides, swept away ventilators, smashed cabin windows and stove in doors. The Captain called it the heaviest storm he had ever experienced. Captain Murray of the steamship ALASKA said the wind "blew a hurricane," and estimated its velocity at 70 miles per hour.

Some 30 funeral processions bound for Calvary Cemetery on Long Island on Monday had stalled in snowdrifts; bodies had to be taken into nearby houses overnight. Several horses and carriages were completely covered with snow, and drivers and mourners narrowly escaped death. In one instance, a party of four had to be dug out and carried unconscious to a nearby hotel.

Two days later, an undertaker started for the New Catholic Cemetery on West Side Avenue to bury Martin King. At Bolton and Montgomery streets the snowdrifts were impassable. The undertaker produced two hand sleds, lashed the coffin to them, and pulled it to the cemetery leaving the mourners to manage the passage as best they could.

On Wednesday, with the streets still buried under snowdrifts and temperatures still frigid, Adolph Osborne, a wealthy lawyer, applied to the court for a dispossess notice to evict Mrs. Mary McMahon, a widow, from a tenement he owned.

"I don't dispossess anybody today," said Justice Kenna, to the cheers of the crowd of loungers in the courtroom, which had already begun to heckle Osborne.

"But I want this woman put out," said the lawyer.

"Well you can't get it done through me."

"But I want my rent," said Osborne.

"I can't help that. You will just have to wait."

Osborne left the court, "followed by the taunts of the crowd."

New York City streets remained clogged with snow for days after the storm. Thousands of men worked to remove an estimated 20 million cubic feet of snow. (Photographs from the Library of Congress)

The Blizzard of '88 was not the most violent storm ever to visit the Northeast. Maximum wind velocities recorded ranged from 48 miles per hour at New York City, to 60 miles per hour at Atlantic City, and 70 miles per hour at Block Island. The winds accompanied a severe cold wave of unusual duration and an almost unprecedented snowfall. It was this combination that so indelibly imprinted itself upon the memory of those who experienced it. As a result, the storm became a legendary event, and many parents named babies born during its visit "Snowflake," "Snowdrift," "Snowdrop," "Storm," "Tempest," and even "Blizzard" to commemorate the event.

Other veterans formed clubs to meet annually on March 12, the anniversary of the storm. One of these, "The Blizzard Men of 1888," was still meeting in New York City as late as 1941, to award a silver cup for the most interesting personal account of the storm.

The Blizzard of '88 impressed the Government, as well as the people. The Nation's Capital was completely cut off from the rest of the country for almost 24 hours. Said a United States Senator: "We cannot control the elements . . . we can protect our communications . . . wires now running overhead must be placed underground in urban areas and thus shielded from the caprices of nature. Not only are the overhead wires unsafe and unsightly . . . they are a damned menace to the security of the United States of America."

Within a few years, city telegraph and telephone wires did go underground. □

Snowbound in New Jersey

The following is the personal account of a gentleman caught by the storm during a Sunday visit to friends in Jersey City Heights, and of his attempt to return to New York City on "Blizzard Monday."

It never for a moment occurred to me to regard this storm as a thing to prevent me from getting to New York. I thought, of course, that owing to the high winds and the isolated condition of the house that there was more snow there than anywhere else, and that as soon as I got out into the regular streets it would be all right. The Jackson avenue station of the New Jersey Central was only five or six blocks from the house, and I anticipated not the slightest trouble in getting there. . . . I bade my friends a fond adieu and started for town. It was still snowing and blowing . . ., and not a print had been made in the snow about the house. . . .

A great bank of snow, piled up against the shrubbery lining the sidewalk confronted me, but I could see comparatively clear valley on the other side and I took a running jump to clear it. . . . (The) top of my hat was the first part of my person to strike the snow, and my head and neck and the greater portion of my fall overcoat followed it into the freezing hole it made. This wasn't pleasant, but with melted snow going down my trousers leg into my boots, I got out to the gate and into the "street," and was then able to discover the real snow.

It was everywhere. Great piles of it rose up like gigantic arctic graves . . . in all directions. Every way that I turned I was confronted with these awful mounds. I took my bearings and steered for the Jackson avenue station. Every step I took I went in to my knees in the snow and every other step I fell over on my face and tried to see how much of the stuff I could swallow. The wind was at my back and its accompanying snowflakes cut the back of my head and my ears like a million icy lashes. . . .

I . . . plowed my way, jumping, falling, and crawling over the drifts, some of which were nine or ten feet high, and regaining my wind in spots where the snow had been driven away, and after an hour and ten minutes I got at the end of my six blocks. There were trains there, two of them, but they were stuck as fast as if somebody had suddenly dumped hogsheads of mucilage about them. There were passengers in them, too, half-frozen and wholly disgusted, some of them women. . . . There had been one train run through in the morning, but that was all. . . .

I gave up the idea of going to New York. . . . My trip back to the house was simply awful. The wind was straight in my face and beat so in my eyes that I couldn't see a rod before me. My mustache was frozen stiff, and over my eyebrows were cakes of frozen snow. My gloves were of kid, and by the time I had gotten halfway back I thought my hands would break off at the wrists. I stumbled along, falling down at almost every step, burying myself in the snow when I fell, struggling frantically up only to sink deep down again. Then I began to feel like a crazy man. Every time I fell down, I shouted and cursed and beat the snow with my fists. I was out there alone, and I knew it, and if I should get down some time and not be able to get up I knew that I might just as well say my prayers. Then it got dark. The wind howled and tore along, hurling the icy flakes in my face, and the very snow on the ground seemed to rise up and fling itself upon me.

In one of my crazy efforts to forge ahead, I caught just a glimpse of the welcome gate posts, and then I laid down on my back and "hollered." I felt as if I couldn't move a limb if $40,000,000 was held above me. Somebody heard my cries, and just as I was going off comfortably to sleep my friend came plowing out through the snow, and he and his man dragged me into the house. □

—*New York Times, March 16, 1888*

Survive The Storms Of Winter

Strictly speaking, the term "blizzard" applies only to winter storms with winds of at least 35 miles per hour accompanied by considerable falling or blowing snow and temperatures of 20 degrees or lower for an extended period.

But it doesn't take a blizzard or even a record storm to be a killer. Statistics show that, of several thousand people killed by winter storms over a 30-year period:

—About a third died in storm-related accidents, primarily in automobiles.

—A little less than a third succumbed to heart attacks induced by overexertion in heavy snow.

—About one-tenth froze to death.

—The remainder died from such varied mishaps as home fires, carbon-monoxide poisoning, falls on slippery pavements, electrocution by downed wires, and collapse of snow-laden buildings.

NOAA's National Weather Service has some suggestions for winter storm survival.

In the home:

The theme should be self-sufficiency—getting ready to live without normal utilities and services. Assume there will be no electricity, no central heating, no deliveries, no way to get groceries, no way to get out for a day or two—and plan accordingly.

Check your battery-powered equipment such as flashlights and radios; make sure batteries are fresh. Have an emergency heating system. Stock extra food, including some that requires no cooking. Look for potential fire hazards from prolonged use of stoves, fireplaces, space heaters.

If you're not in the pink of condition, keep in mind that heart failure from shoveling snow is a major cause of death in winter storms. Remember that mittens are warmer than fingered gloves, that several layers of loose-fitting clothing provide better protection against cold than tight-fitting garments; that outer wear should be tightly woven, water repellent and hooded.

On the road:

Winterize the family car in advance. Have ignition, fuel, antifreeze, and exhaust systems checked. Make sure the heater is working, that brakes are tight and in adjustment, tires in good condition, windshield wiper and lights working properly.

In rural areas or when extended travel is planned, be ready for the worst. Have a car kit ready. Among items to consider are tire chains, tow chains, snow shovel, sack of sand, flashlight or signal light, flares, extra gasoline, fire extinguisher, booster cables, axe, windshield scraper, external heater, first-aid kit, knife, compass, road maps, blankets or sleeping bags, paper towels, matches, candles, extra clothing, pliers, screwdriver, and adjustable wrench.

Before setting out, check the latest weather information. On the road keep the radio on for storm bulletins. Maintain as much gasoline in your tank as you can, stopping frequently to refill. In remote areas, travel in convoy with another vehicle if you can; try not to be caught alone. When conditions worsen rapidly, seek refuge immediately.

If a blizzard traps you on the road, try to stay in the car. This is where rescuers are likely to find you soonest. If you're in deep, don't try to push two tons of car out of a drift or risk a heart attack by frantic shoveling. Don't try to walk out through a blizzard. Getting lost can be almost certain death.

While waiting for help, keep the passenger compartment ventilated by opening a window just a bit. Run the motor and heater sparingly. Carbon monoxide is a stealthy killer. Try not to remain motionless for long periods. Exercise by clapping hands and moving arms and legs vigorously. At night, turn the dome light on so work crews can spot you easily. Keep a continuous watch. Never allow all occupants of the car to sleep at once.

it all began with the ARK

BY GRACE WEGNER

The family tree of Lake Survey vessels shows an evolution from sailing schooners and paddlewheelers to modern charting ships.

Diving to the wrecks of yesteryear is a fascinating and sometimes profitable hobby for many an amateur and professional diver today. Since the first ship ever to sail the Great Lakes—the little 45- to 60-ton GRIFFIN, built by the intrepid French explorer, LaSalle, to transport the rich cargo of furs he and his men had collected—disappeared on September 18, 1679, many ships have been known to sail off and vanish forever without a trace in the deep, often violent, waters of the Great Lakes. Pieces of wreckage washed up on shore gave evidence of the fate of others.

By the early 1800's, the toll was so great that the need for accurate charts of these important water highways was a recognized necessity. This was a direct factor in the establishment of the U.S. Lake Survey, now the Lake Survey Center of the National Ocean Survey.

In those bygone days when there were no railways, roads were rough and few, and hostile Indians roamed much of the territory, the waterways played a vital role in both fur trade and colonization. Charts, as we know them, were not available to guide the adventurous old-time sailor. The best guide he could obtain was called a "meandering." Although the meandering showed the general shape of the shoreline, it did not include soundings, astronomical positions, shoals, reefs, accurately positioned landmarks, or natural channels. Such features, so essential to the ship navigator, were not provided to the navigator of these vast and often treacherous inland seas until the Lake Survey was organized in 1841 to provide official charts of what were then called the "Northern and Northwestern Lakes"—the Great Lakes.

The charting job required ships, and throughout its more than 130 years' service in the area, the Lake Survey has used many types. These have included row-boats, Mackinac boats (flat-bottomed boats with sharp bow and square or pointed stern, using oars or sails or both), small sailboats, whaleboats, a schooner, various types of rafts and catamarans, steamers, launches, motor ships, and even canoes.

The first large vessel used by the Lake Survey was named the ARK, but it is not known whether this ship was a steamer or a sailing vessel. The only reference to it was made in a passage of a private diary written

by W. H. Hearding, an eminent engineer who began his career with the Lake Survey in 1851. The following is a direct quote from his diary: "The flagship of the Survey was a kind of a barge, Lt. J. N. Macomb in charge; she was named the 'ARK' possibly from the fact of his using her in the surveys of Maumee and Sandusky Bays, and mooring her in the bullrushes which abound in their vicinity."

The second acquisition was the Steamer ABERT, named for the then Chief of Topographical Engineers, Colonel J. J. Abert. She was built especially for water survey work. A U.S. Navy lieutenant, W. W. Hunter, was assigned the task of designing and constructing her. This he did. And what a ship! Lt. Hunter had some slightly bizarre ideas, and he put them into practice. Lake Survey ended up with an unusual craft, even for the early 1800's, and it is doubtful if any other vessel before or since has had the same unique type of propulsion incorporated under Lt. Hunter's direction. The ABERT had an iron hull, was 96 feet long, had an 18½-foot beam, and a draft of 3½ feet. She was propelled by side paddle wheels, though not used in the conventional way. Herein was the lieutenant's *piecè de résistance*—they were set in a *horizontal* position, under the ship! Mr. Hearding's diary facetiously says of it: "But no great assistance was realized through her, until the wheels were changed to a *vertical* position; as in a good strong headwind, she did not make more than a knot an hour, and that was astern."

Some authorities believe that the ABERT was the first iron-hulled steamer "west of the Niagara River." However, others maintain that the USS MICHIGAN (the first Navy iron-hulled gunboat; incidentally, purchased by the Government at 13½ cents a pound launched!) launched at Erie, Pennsylvania, on December 6, 1843, beat it by about one month. The ABERT was renamed SURVEYOR about 1846.

It soon became apparent that charting the nearly 100,000 square miles of Great Lakes waters would require more vessels and more men if the work were to be done in a reasonable length of time. So, in 1845, shortly after the Lake Survey moved from its original site in Buffalo to Detroit, the Steamer CHAUTAUQUA was chartered. Sketchy early records give no clue as to either her dimensions or how long she was used.

Many of the surveys completed during the late 1850's were made under the direction of Captain George G. Meade, Corps of Topographical Engineers, who served as District Engineer from 1857-61. This was the same Meade who was promoted to Brevet Brigadier General in the U.S. Volunteers in August 1861 and to the same rank in the Regular Army in July 1863, and was in command of the Union Forces during the Battle of Gettysburg in the Civil War. During Captain Meade's tenure as District Engineer of Lake Survey, a new flagship, an iron side-wheel steamer, 143 feet long, with a 21-foot beam and eight-foot six-inch depth, was commissioned. She was originally christened the JEFFERSON DAVIS, in honor of the then Secretary of War. However, the name had been changed to SEARCH before she was delivered.

In 1859, Lieutenant Orlando M. Poe (later appointed Lake Survey District Engineer and still later made Brigadier General and honored by having one of the world-famous Soo Locks named for him) was in charge of a survey party and assigned the sailing schooner COQUETTE (a charter ship, renting for $200 per month) to carry out the work. The COQUETTE was the only large sailing vessel used by the Lake Survey. (Smaller sailing craft, such as the Mackinac boats, were used principally for short-range travel or to move supplies.) No mention is made as to whether or not the ship was ever purchased outright. Each spring, the COQUETTE was fitted out at the Government Dock in Detroit and, after the crew and supplies were put aboard, she was towed, along with five or six other sailboats, by tug to Port Huron. Here, she was cut loose and, canvas raised, she traveled about Lake Huron under sail. From a journal of the SURVEYOR on July 31, 1859, comes the brief mention, "The surveying Schooner COQUETTE came into Presque Ile last evening. D. Poe dined us and we had him to tea."

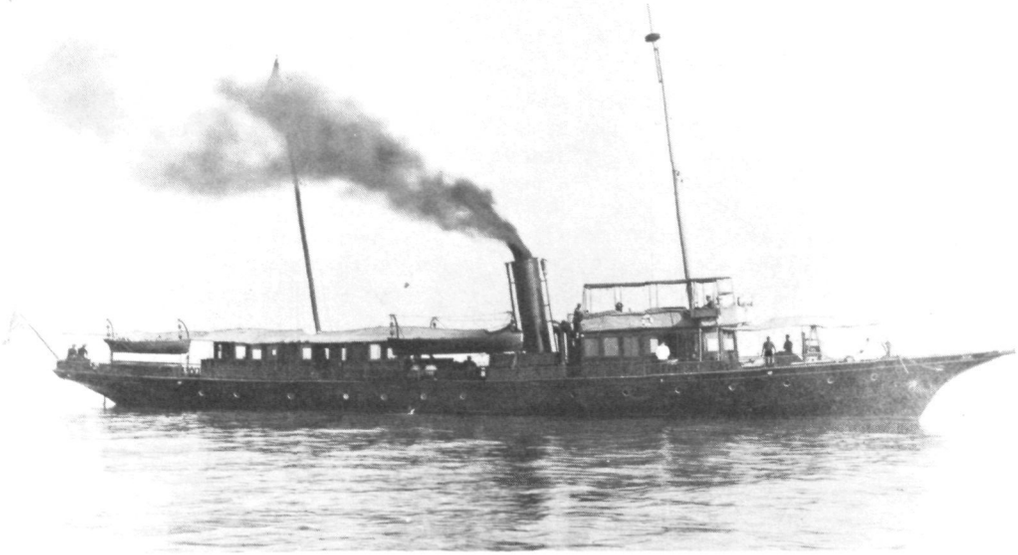
The COQUETTE served well, but on October 13, 1864, she was stranded on the rocks at Rock Island in Green Bay, Lake Michigan. Here, since the damage to her wooden hull was extensive, she was abandoned after the supplies and her rigging were removed.

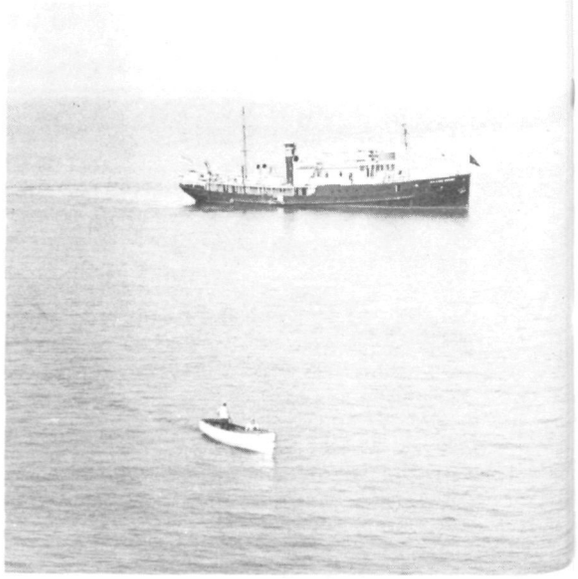
In October of 1865, the Steamer LITTLE ADA was purchased from the U.S. Navy. This ship had an iron hull, was 122 feet long, had an 18-foot beam, and a draft of nine feet six inches. She had been built in Scotland and her early history included a stint as a blockade runner by the British to aid the Confederacy during the Civil War. This clandestine service was brief, however, for she was soon captured by the U.S. Navy.

After extensive alterations to make her suitable for survey operations, her name was changed from LITTLE ADA to just plain ADA, though many of her crew when referring to her in their reports affectionately still called her LITTLE ADA. After thirteen years of faithful service, she was sold. Her life after that led to numerous changes and alterations in her superstructure to meet the conditions of merchant service to which her various owners put her. The last name she carried was POLLING BROS. No. 2. Bearing that name she was stranded on May 12, 1940, on Captain Island, New York, and was declared a total loss, thus ending a remarkably long and checkered career of over 75 years, a record of service not too many ships could match.

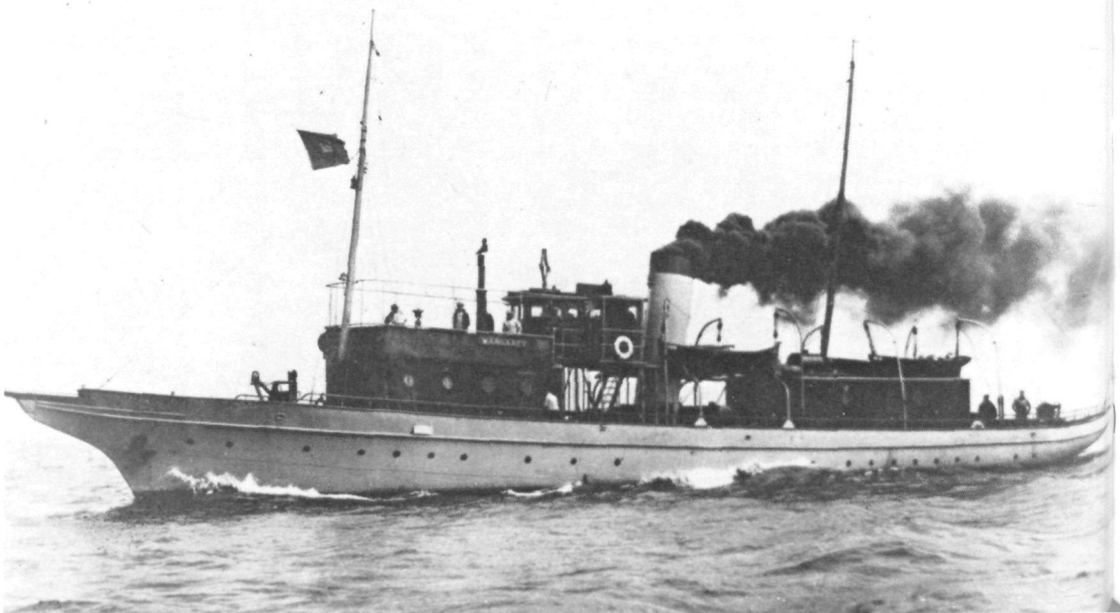
continued

(Opposite page) Around the turn of the century, the Lake Survey used catamarans to measure the flow of water in large rivers. (Below) Survey crew aboard the VIDETTE, which began operating on the Great Lakes in 1901.





(Top left) The steel-hulled steamer SEARCH, built in 1896 as a racing boat, became a hydrographic vessel in 1899, after serving the Navy in the Spanish-American War. (Top right) The JOHNSON, first water-jet propelled catamaran-type survey vessel, made her debut on the lakes in 1962 and is still in use. (Above, left) the WILLIAMS served the Lake Survey from 1946 to 1960. (Above, right) The PEARY and a cutter conduct sweeping operations in 1937. This ship had been used in the 1925 Byrd-McMillan Polar Expedition. (Right) the steamer MARGARET, which sank at the dock at Port Crescent in 1926 as the result of a storm, was raised, recommissioned, and went on to make the survey which discovered the Lake Superior Shoal in 1929.



By 1871, the Lake Survey had increased considerably in size, both in the number of its ships and its personnel. Since vital statistics are missing from many of the official records and only the names of the ships appeared, it is assumed that the six new ships used that year were either chartered or borrowed (and possibly purchased later, though no evidence of this has been found) from other Corps Districts. Those mentioned in the 1871 reports were the GENERAL MEADE, GRAND ISLE, JENNIE, NADINE, D. W. POWERS, and the UNDIEU.

During the days when the small workboats were powered by oars, hand lead soundings were taken, and the men had to make do with any means at hand to carry out their mission, the leader of the survey team had to cope not only with the elements of nature and his limited equipment, but also with man's inherent weaknesses, including superstition.

One such incident took place in 1871, when a member of the SURVEYOR's crew was killed accidentally on the job. In a report to headquarters, the steamer's commanding officer wrote:

> Since this unfortunate occurrence the men have seemed paralyzed, and they are . . . extremely superstitious. . . . Yesterday, two men left the Steamer, one the leadsman (the only one on board), the other a wheelsman. They could not be induced by either persuasion or threats to remain. This leaves me in addition to other disadvantages which I stated to you verbally with two wheelsmen only, and one of them is only about, after having been very low with fever, and able only for very light duty for short intervals. The other wheelsman is blind in one eye and at times is subject to turns resembling partial insanity and at these times is entirely unfit for this duty. . . .
>
> Very respectfully
> Your Obe'dt. Serv't.
> /s/
> Jared A. Smith
> Captain of Engineers
>
> P.S. Since the foregoing one of the men has returned, and although I cannot but feel it contrary to good discipline, the necessities of the case are such that I have acceded to the request of the boat's officers and returned him to his place.
>
> I am compelled to use my carpenter on board as second officer of the boat, and he has therefore to be on duty nearly all the time. I would therefore respectfully ask that his per diem be increased from $2.00 to $2.50 as he is earning at least as much as the last named amount and his present pay was not established for such unusual services.
>
> Very respectfully
> J. A. Smith
> Capt. of Engrs.

Many ships have served Lake Survey well, then gone on to their place in history. Some of them were: the MARTHA (1872); HANCOCK (1890); SCOTIA (1892); ANTELOPE (1895); Catamarans Nos. 1, 2, and 3 (1898-99); the second Steamer SEARCH (1899); Steamer VIDETTE (1901); the second Steamer SURVEYOR (1903); Steamer GENERAL WILLIAMS (1904); the NETNOKWA (1916); MARGARET (1920); PEARY (1930); Launch HASKELL (1936); the WILLIAMS, F. G. RAY, and MACDERMID (all in 1946); and the DEPAGTER (1955). In recent years, the Catamaran JOHNSON (1962), the Research Vessel SHENEHON (1964), and the LAIDLY (1967) have become the mainstay of the fleet.

Each new ship brought with it innovations and improvements. Until about 1910, most hydrographic surveying involved the determination of depths at selected points only. When these points were close to shore and of comparatively shallow depth, the pole or the light hand-lead was used from a small boat. In the deeper outlying areas, the deep-sea, or heavy lead was used from the steamer, the handling of this lead and its attached line requiring the services of several men. The lead was hauled inboard after each sounding, and in depths exceeding 20 to 25 fathoms (120-150 feet), it was necessary to stop the steamer for each sounding in order to get a vertical depth.

Around the turn of the century, as an improvement on this laborious method, the Lake Survey supplied its steamer parties with sounding machines. These used fish or projectile-shaped iron weights suspended from piano wire of small diameter, the wire being run on and off a drum by easily manipulated mechanism, which also operated a recording apparatus, so that depths could be read without raising the weight above the water.

In 1928, an electronic fathometer ("echo sounder") was put into service for the first time on the Great Lakes, increasing the speed of making the hydrographic surveys. In August 1929, the MARGARET, equipped with one of these primitive sounding instruments, discovered a shoal in Lake Superior. Due to the novelty of the electronic device, when Bob Hansen, one of the members of the survey crew, reported the obstruction, Harry F. Johnson (whose name was given to a later vessel), the engineer-in-charge, was half tempted to pass it off as one of the "bugs" in the equipment. However, on retracing their lines, it was found that there was, in fact, a shoal, and it was subsequently named the SUPERIOR SHOAL. One rock in mid-lake on the vessel course between Passage Island and Michipicoten Island lies about 21 feet below the surface of the water, has a diameter of about 100 feet, and is entirely surrounded by deep water. It may have been one reason for the mysterious disappearance of some of the ships which vanished without a trace. Another might well be the physical conditions on the lake itself. Lake Superior has the dubious reputation of being the largest, deepest, and coldest of all the Great Lakes. Ships traveling this lake in the fall were—and still are—subject to sudden and often ferocious storms. In the days before radio and other means of communication were standard equipment, it is possible that in some cases a ship proceeding through the raging waters might be covered so thickly with freezing spray that the sheer weight of the ice would cause it to slip silently into the depths, with no one or no way to tell what had happened.

In 1930, a 145-foot, 350-ton displacement steamer named the BRETZEN (which had been used in 1925 in the Byrd-McMillan Polar Expedition to the Arctic region) was purchased to modernize the fleet. This was one of three sister ships built in 1918 at Fort Williams, Ontario, for the French government mine-sweeping fleet. Several years before, two of the three vessels had simply vanished on Lake Superior (perhaps victims of the Shoal) while on a voyage to Sault Sainte Marie. By a quirk of fate, this ship, which was to become the Lake Survey's PEARY, was the lone survivor of the voyage and returned to perform many important surveys in the area.

The PEARY was replaced by the WILLIAMS (named for Lake Survey's first District Engineer, Captain W. G. Williams, Corps of Topographical Engineers) in 1946. The 143-foot WILLIAMS had been designed and built in 1944 for the Army Transportation Corps (where her name had been simply LT 956) by the Livingston Ship Building Company at Orange, Texas. When the Lake Survey acquired her, she was modified to extend the forward mast to raise the Shoran antenna units which were in use by that time. The WILLIAMS, later renamed the BARTLETT H. INGRAM, was transferred to the St. Lawrence Seaway Development Corporation, Ogdensburg, New York, in 1960, shortly after the opening of the St. Lawrence Seaway. In November 1961, she officially became a merchant vessel and during October 1962, she cleared the Lakes for New York City, where she was transferred to Pakistan. Presumably she is still plying her trade there.

In 1951, electronic positioning of survey vessels was used on the Great Lakes for the first time; and in 1962, the first water-jet propelled catamaran-type survey vessel (possibly the world's first of its size and type) made her debut in the area. This ship, the JOHNSON, run by twin water-jet units directly driven by diesel engines, is still part of the Lake Survey Center's fleet. She is double-hulled, all-welded aluminum, 50 feet in length, has an 18-foot beam, and a draft of less than five feet. She can be operated in seas far heavier than would be possible with a mono-hull vessel of similar length. The JOHNSON is completely equipped with the latest navigational and survey equipment—gyrocompass, full spherical magnetic compass, radar, eight-channel ship-to-shore radio-telephone with 100-watt output, depth recorders, power capstan, FM radio communication system, sweeping equip-

continued

(Above) The newest in the Lake Survey's fleet of vessels is the 54-foot LAIDLY. (Right) The SHENEHON was added to the fleet in 1964 for water sampling and testing programs.

ment for small wire sweep surveys, a 16-foot welded aluminum outboard-powered work boat, and all safety devices required by the U.S. Coast Guard for small passenger vessels, including a 12-man inflatable life raft and a CO_2 fixed fire extinguishing system. During surveying operations, she uses the latest electronic positioning system available.

The SHENEHON—a research vessel needed to meet the demands of Lake Survey's ever-increasing activities in this field—was added to the fleet in 1964. This vessel, originally known simply as T-465, belonged to the U.S. Army Transportation Corps and was designed to carry men and materials, particularly in harbor areas. Constructed to be taken aboard larger vessels and then off-loaded for duty in selected harbors, the ship was built at Leavenworth, Kansas, and upon completion in 1953 was transported to Charleston, South Carolina, where she was immediately placed in "mothballs."

Some ten years later, the Lake Survey's search for a vessel to be used in conducting the various water sampling and testing efforts necessary to support its Water Characteristics Project led to the T-465. After investigating various other sizes and types, arrangements were made to obtain this ship on a loan basis from the Army Materiel Command at Charleston (she has since officially become the property of NOAA). She was transported by barge from that city, up the Mississippi River to Joliet, Illinois, where she was put into the water for the first time since being built. The Corps of Engineers Boatyard in Detroit was her next stop, and it was there that the necessary modifications and changes were made and scientific equipment added to prepare her for her first assignment as a full-time research vessel and floating laboratory. When her transformation was complete, she was commissioned and officially named the SHENEHON (for Francis C. Shenehon, Chief Civilian Engineer at Lake Survey from 1906-09) at ceremonies in Detroit on June 25, 1965.

The latest in the Lake Survey's fleet of survey vessels is the 54-foot LAIDLY. She was built after almost seven years of study to design a ship suited for the agency's specialized needs as official chartmaker for the Great Lakes area. This ship, as were most others acquired from 1936 on, was named in honor of a distinguished former Chief Civilian Engineer of Lake Survey, William T. Laidly. She was dedicated on May 16, 1967, at the Belle Isle Coast Guard Station in Detroit. The LAIDLY is fitted out with the latest available equipment and, with her excellent speed (cruising, 20 miles per hour; maximum, 24 miles per hour) has eliminated the need for "trailering" between survey sites, thus saving both time and money, as well as increasing efficiency.

Of the men who operated these ships, many tales survive. They include the continuing saga—almost like a radio serial for several days—of the crewmen suffering from "Purpurien Hemmoragical" who, as mentioned in the log of the SURVEYOR on June 2, 1866 (and for a number of days thereafter), "was bleeding at the nose for 17 hours," and for whom a doctor had to be taken aboard the ship where he spent the better part of two weeks ministering to the man. Though it was touch and go for a while, it ended happily, as after several setbacks the patient finally recovered and went back on duty.

Or they describe how, during some of the earlier surveys, men were kept from their usual tasks by forest fires with smoke so dense they "could not see to work," or when rain, fog, wind, and heavy seas kept the men aboard and they had to spend their hours "cleaning flues and boilers and doing other jobs around the ship." They tell of the friendly rivalry and excitement of early crews as they raced their vessels during Fourth of July celebrations, as (taken from a list of general directions given a leader of a survey party setting out in 1869), ". . . it is absolutely necessary when isolated from the world, that you should make the time pass as pleasantly as possible. . . ." (when not working, of course).

They include the predicament of the Safety Officer who put out in a small boat to photograph a ship's crew dressed in bright-colored safety gear. Concentrating on his photography he forgot that there were no oars in his little craft. Having drifted some distance from the surveyboat, he had to call for rescue by the crew.

The latest tale is that of the LAIDLY, whose crew not only rescued the occupants of a capsized sailboat, but retrieved their craft as well.

The times, the ships, and the methods of operation have changed, but it is still a dedicated band of men that works on the inland seas. □

Sea Fare

SHAPING UP WITH SEAFOOD

If you added a few pounds during the holiday season, now's the time to lose them.

Crash dieting is the hard way. You wind up with an empty feeling and a bad disposition.

An easier—and healthier—way is to plan your meals around fish and shellfish. Fill up on seafood and slim down at the same time.

Eating enjoyment is an important part of dieting. To stay with a diet until the goal is reached, the dieter needs foods that give a sense of satisfaction as well as nourishment. Fish and shellfish impart vitality and a well-fed feeling, because they are a complete protein food—85-95 percent digestible, rich in energy-giving vitamins and minerals. An average serving of seafood provides nearly all the animal protein that is needed each day to help the dieter build and repair body tissue. In addition, fish and shellfish are lower in calories than most other protein sources.

The recipes here were prepared by the National Marketing Services Office of the National Marine Fisheries Service, and others are included in its booklet, "Seafood Slimmers," (Fishery Market Development Series No. 7 (I 49.49/2:7) available for 25 cents from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Lose weight, feel better, and enjoy your diet with fish and shellfish.

MINTY SEA SALAD

1½ pounds skinless pollock fillets, fresh or frozen
2 cups boiling water
¼ cup lime juice
1 teaspoon salt
Mint Dressing
Lettuce
Cherry Tomatoes
Mint sprigs

Thaw frozen fillets. Cut fillets into 6 portions. Place fish in a well-greased 10-inch fry pan. Add boiling water, lime juice, and salt. Cover and simmer for 10 to 12 minutes or until fish flake easily when tested with a fork. Drain. Flake fish. Pour Mint Dressing over fish. Cover and chill for at least two hours. Serve on lettuce. Garnish with cherry tomatoes and mint sprigs. Makes 6 servings.

Mint Dressing

½ cup salad oil
⅓ cup lime juice
1½ teaspoons dried mint leaves, crushed
1½ teaspoons sugar
½ teaspoon garlic salt
Dash liquid hot pepper sauce

Combine all ingredients. Makes approximately ¾ cup dressing.

STRIPED BASS WITH LOW-CAL STUFFING

3 pounds dressed striped bass or other dressed fish, fresh or frozen
1½ teaspoons salt
Low-Cal Stuffing
2 tablespoons melted fat or oil
Lemon wedges

Thaw frozen fish. Clean, wash, and dry fish. Sprinkle inside and out with salt. Stuff fish loosely. Close opening with small skewers or toothpicks. Place fish on a greased bake and serve platter, 16x10 inches. Brush with fat. Bake in a moderate oven, 350° F., for 40 to 60 minutes or until fish flakes easily when tested with a fork. Remove skewers. Serve with lemon wedges. Serves six.

Approximately 310 calories in each serving.

Low-Cal Stuffing

¾ cup chopped onion
1½ tablespoons butter or margarine, melted
2¼ cups chopped, peeled apple
⅓ cup chopped celery
⅓ cup chopped parsley
2 tablespoons lemon juice
¼ teaspoon salt
⅛ teaspoon thyme

Cook onion in butter until tender. Combine all ingredients and mix thoroughly. Makes approximately three cups stuffing.

KEY LIME MULLET

2 pounds mullet or other fish fillets, fresh or frozen
1 teaspoon salt
Dash pepper
¼ cup lime (or orange) juice
3 tablespoons butter or margarine, melted
Paprika
Lime (or orange) wedges

Thaw frozen fillets. Skin fillets and cut into serving-size portions. Place fish in a single layer in a shallow baking dish. Sprinkle with salt and pepper. Pour fruit juice over fish and let stand for 30 minutes, turning once. Remove fish, reserving juice. Place fish on a well-greased broiler pan. Combine butter and juice. Brush fish with butter mixture and sprinkle with paprika. Broil about four inches from source of heat for 8 to 10 minutes or until fish flakes easily when tested with a fork. Serve with fruit wedges. Serves six.

Approximately 130 calories in each serving.

HEARTY HALIBUT

2 pounds halibut steaks or other fish steaks, fresh or frozen
⅔ cup thinly sliced onion
1½ cups chopped fresh mushrooms
⅓ cup chopped tomato
¼ cup chopped green pepper
¼ cup chopped parsley
3 tablespoons chopped pimiento
½ cup dry white wine
2 tablespoons lemon juice
1 teaspoon salt
¼ teaspoon dill weed
⅛ teaspoon pepper
Lemon wedges

Thaw frozen steaks. Cut into serving-size portions. Arrange onion in bottom of a greased baking dish, 12x8x2 inches. Place fish on top of onion. Combine remaining vegetables and spread over top of fish. Combine wine, lemon juice, and seasonings. Pour over vegetables. Bake in a moderate oven, 350° F., for 25 to 30 minutes or until fish flakes easily when tested with a fork. Serve with lemon wedges. Serves six.

Approximately 230 calories in each serving.

FISHKABOBS

2 pounds salmon steaks, fresh or frozen
1 pound halibut steaks, fresh or frozen
1 pound scallops, fresh or frozen
3 green peppers, cut into 1-inch squares
2 cans (16 ounces each) small white onions, drained
1 tablespoon garlic powder
1 tablespoon oregano
1 tablespoon salt
1 tablespoon thyme
1 teaspoon pepper
2¼ cups oil

Thaw frozen steaks and scallops. Cut salmon and halibut steaks into approximately 48 one-inch chunks. Rinse scallops with cold water to remove any shell particles. Alternately thread four pieces fish, two scallops, three pieces green pepper, and three onions on 12 skewers, approximately 12 inches long. Place kabobs in a single layer in a shallow baking pan. Combine garlic powder, oregano, salt, thyme, and pepper. Sprinkle over kabobs. Pour oil over kabobs and let stand one hour, turning once. Drain. Place kabobs on a grill, about four inches from moderately hot coals. Cook about four to six minutes. Turn carefully. Cook for four to six minutes longer or until kabobs are brown and fish flake easily when tested with a fork. Makes 12 servings.

DUNGENESS CRAB RAMEKINS

1 pound Dungeness crabmeat or other crabmeat, fresh or frozen or
3 cans (6½ or 7½ ounces) crabmeat
1 tablespoon butter or margarine
2 tablespoons flour
1 cup skim milk
2 slices bread, cubed
1 can (4 ounces) mushroom slices, drained
2 tablespoons dry white wine
1 tablespoon lemon juice
1 tablespoon chopped parsley
¼ cup grated Swiss cheese
Paprika

Thaw frozen crabmeat. Drain crabmeat. Remove any remaining shell or cartilage. Cut crabmeat into bite-size pieces. Melt butter and blend in flour. Add milk gradually and cook until thick and smooth, stirring constantly. Combine all ingredients except cheese and paprika. Place in six well-greased six-ounce casseroles or custard cups. Top each casserole with cheese and sprinkle with paprika. Bake in a hot oven, 400° F., for 15 to 20 minutes or until bubbly and cheese melts. Makes six servings.

Approximately 145 calories in each serving.

CANTONESE SHRIMP AND BEANS

- 1½ pounds frozen raw, peeled, deveined shrimp
- 1½ teaspoons chicken stock base
- 1 cup boiling water
- ¼ cup thinly sliced green onion
- 1 clove garlic, crushed
- 1 tablespoon salad oil
- 1 teaspoon salt
- ½ teaspoon ginger
- Dash pepper
- 1 package (9 ounces) frozen cut green beans
- 1 tablespoon cornstarch
- 1 tablespoon cold water

Thaw frozen shrimp. Dissolve chicken stock base in boiling water. Cook onion, garlic, and shrimp in oil for three minutes, stirring frequently. If necessary, add a little of the chicken broth to prevent sticking. Stir in salt, ginger, pepper, green beans, and chicken broth. Cover and simmer five to seven minutes longer or until beans are cooked but still slightly crisp. Combine cornstarch and water. Add cornstarch mixture to shrimp and cook until thick and clear, stirring constantly. Serves six.

Approximately 130 calories in each serving.

COD PROVENCAL

- 2 pounds cod fillets or other fish fillets, fresh or frozen
- 1 can (16 ounces) tomatoes
- ½ cup chopped onion
- 2 tablespoons butter or margarine
- 1 teaspoon salt
- ½ teaspoon basil
- ½ teaspoon garlic powder
- ¼ teaspoon pepper
- 2 tablespoons chopped olives

Thaw frozen fillets. Skin fillets and cut into 6 portions. Drain tomatoes and cut into ½-inch pieces. Cook onion and fish in butter in a 10-inch fry pan for five minutes, turning once. Sprinkle fish with seasonings. Add tomatoes. Cover and simmer five to ten minutes longer or until fish flake easily when tested with a fork. Sprinkle with olives. Makes six servings.

Approximately 145 calories per serving.

KING CRAB-CELERY VICTOR

- 2 packages (6 ounces each) king crab meat or other crab meat, fresh, frozen or pasteurized
- or
- 2 cans (6½ or 7½ ounces each) crab meat
- 2 celery hearts
- 2 chicken bouillon cubes
- 3 cups boiling water
- 1 cup low calorie French dressing
- 6 large lettuce cups
- Pepper

Thaw frozen crab meat. Drain crab meat. Remove any remaining shell or cartilage. Cut crab meat into one-inch pieces. Wash and trim celery hearts so that they are about five inches long. Cut each heart into thirds lengthwise. Place celery in a 10-inch fry pan. Dissolve bouillon cubes in boiling water and pour over celery. Cover pan and simmer for 10 to 15 minutes or until tender. Let celery cool in bouillon. Drain. Place celery in a shallow baking dish. Pour French dressing over celery and chill for at least two hours. Remove celery from dressing. Drain. Place in lettuce cups. Sprinkle with pepper. Place approximately ¼ cup crab meat on celery. Serves six.

Approximately 70 calories in each serving.

SAVORY BAKED HADDOCK

- 2 pounds haddock or other fish fillets, fresh or frozen
- 2 teaspoons lemon juice
- Dash pepper
- 6 slices bacon, chopped
- ½ cup soft bread crumbs
- 2 tablespoons chopped parsley
- ¾ cup thinly sliced onion
- 2 tablespoons bacon fat

Thaw frozen fillets. Skin fillets and place in a single layer in a greased baking dish, 12x8x2 inches. Sprinkle with lemon juice and pepper. Fry bacon until crisp. Remove bacon from fat. Add to bread crumbs and parsley. Cook onion in bacon fat until tender. Spread onion over fish. Sprinkle crumb mixture over top of onion. Bake in a moderate oven, 350° F., for 25 to 30 minutes or until fish flakes easily when tested with a fork. Serves six.

Approximately 170 calories in each serving.

President Appoints 25-Member Committee to Advise on Ocean-Atmosphere Programs

The direction of the Nation's efforts in the atmosphere and oceans over the next several years will be guided in large measure by a newly appointed, distinguished group of private citizens with a broad range of expertise.

The 25-man group is NACOA—the National Advisory Committee on Oceans and Atmosphere, appointed by President Richard M. Nixon on October 19 and reporting to him and to Congress through Secretary of Commerce Maurice H. Stans.

Its task, under legislation passed by Congress on August 15 of this year, will be to assess all Federal programs in marine and atmospheric science.

In particular, NACOA will advise on the operations and programs of NOAA, created by President Nixon on October 3, 1970, to provide a single national focus for the Nation's civilian efforts in the oceans and atmosphere.

Chairman of the Committee is one of the Nation's foremost oceanographers, Dr. William A. Nierenberg, Director of the Scripps Institution of Oceanography, La Jolla, California. Dr. Nierenberg brings to the post a variety of experience, including work on the Manhattan Project, service as a consultant to the Navy and to private industry, and as a member of the President's Special Projects Committee.

NACOA's Vice Chairman is Dr. William J. Hargis, Jr., an expert in oceanography, fisheries research, Sea Grant programs, and marine resources. Dr. Hargis is Director of the Virginia Institute of Marine Science, Gloucester Point, Virginia, and Chairman of the Coastal States Association.

Of the 25 men appointed by the President, eight will serve for three years, eight for two years, and nine for one year. Thereafter, appointments will be for full three-year terms.

Members named by the President for the full three years were drawn from industry, private meteorology, commercial fishing, and academic institutions. In addition to the Chairman and Vice Chairman, they are:

—Charles F. Baird, former Under Secretary of the Navy, who is now Vice President for Finance of the International Nickel Company, Inc.

—Dr. Wayne V. Burt, Oregon State University's Dean of Research in Oceanography. Dr. Burt has been Associate Oceanographer at Scripps Institution and Assistant Professor at Johns Hopkins University.

—Dr. Charles L. Drake, who is a member of the Department of Earth Sciences at Dartmouth College, and serves on the National Academy of Sciences' Geophysical Research Board and Committee on Oceanography. Dr. Drake has been the prime mover in the new international program called the International Geodynamics Project and chairs both the U.S. and international Committees for the Project.

—Thomas A. Fulham, President of the Boston Fish Market Corporation, and one of three Commissioners of the International Commission for the North Atlantic Fisheries.

Dr. William A. Nierenberg (right), Director of the Scripps Institution of Oceanography at La Jolla, California, received his Presidential commission as Chairman of the National Advisory Committee on Oceans and Atmosphere (NACOA) from Secretary of Commerce Maurice H. Stans at the Committee's first meeting in Washington, D.C., December 8.

—Brigadier General Joseph J. George, USAF (Retired), Director of Meteorology for Eastern Airlines, Miami, Florida, who has served as chairman of the Department of Commerce Advisory Committee on Weather Services.

—Dr. Thomas F. Malone, a nationally known meteorologist who is currently Deputy Foreign Secretary of the National Academy of Sciences and Vice President of the University of Connecticut.

The group serving two years includes members from industry, labor, a State government, and a private foundation, as well as from universities. They are:

—William D. Carey, senior staff consultant with the Arthur D. Little Corporation in Washington, D.C. Mr. Carey was Deputy Director of the Bureau of the Budget from 1959 to 1969 and won the Rockefeller Public Service Award.

—Dr. Dayton H. Clewell, author of a number of papers in the fields of experimental physics, geophysics, and petroleum research, who

NMFS To Gather Statistics on Marine Game Fish Catch

The National Marine Fisheries Service is beginning a Marine Sport Fisheries Statistics Program within its Statistics and Market News Division.

Gathering commercial fishery statistics is a relatively simple matter, since the commercial catch involves thousands of fishing craft, but relatively few landing locations. On the other hand, there are literally millions of salt-water anglers, their activities spread over the entire coastline, from Maine around to Washington State, and including Alaska and Hawaii.

A National Survey of Hunting and Fishing sponsored by the Department of the Interior's Bureau of Sport Fisheries and Wildlife is taken every five years by the Bureau of the Census. The survey is highly useful in determining broad trends, such as which geographic areas are more heavily hunted or fished, and the concentration of sportsmen at various levels of income. However, detailed and accurate figures needed as a basis for fishery conservation measures are not obtained.

As a first step in this direction, NMFS has contracted with a private research firm to develop methods for reducing "response bias" associated with estimating the sport catch from household interviews.

The firm, Audits and Surveys, Inc., of New York City, will test its anti-response bias techniques with a two-month pilot household survey in California. Catch estimates obtained by the pilot survey will be checked against statistics routinely collected by the California Department of Fish and Game. If the techniques work, NMFS will use this method for nationwide surveys to gather the statistical information needed for conservation of marine game fish, with the overall program expected to get underway by 1973.

R. E. Hallgren Is Appointed to Monitoring, Prediction Post

Dr. Richard E. Hallgren has been appointed NOAA's Associate Administrator for Environmental Monitoring and Prediction.

Dr. Hallgren was formerly Assistant Administrator for Environmental Systems, the position he held also in ESSA for a year before the formation of NOAA in 1970.

In the new post, he will provide policy leadership for NOAA's environmental satellite, meteorological, hydrologic, and marine services, for observations taken for prediction purposes, and for data management, and will coordinate NOAA's responsibilities in the World Weather Watch and the Integrated Global Ocean Station System.

In 1953, Dr. Hallgren received his bachelor's degree in meteorology and in 1960 his Ph.D. in meteorology with a minor in physics from Pennsylvania State University.

From 1954-56, he was an Air Force staff weather officer and operational weather forecaster in support of the Strategic Air Command. He joined IBM's Space Guidance Center in 1960 as an operations research analyst and from 1963 to 1964 managed the company's Washington System Center Meteorology Systems Department. For two years, he was Scientific Advisor to the Assistant Secretary of Commerce for Science and Technology and in 1965, became Director of ESSA's Office of World Weather Systems.

SNOW SEEDING PROJECT RESUMED

ERL's Atmospheric Physics and Chemistry Laboratory conducted a field project in the Buffalo, New York, metropolitan region from Nov. 12 to Dec. 15, aimed at obtaining a first reading on the feasibility of changing the snowfall pattern of winter lake storms in a generally beneficial way. Very early results show that cloud seeding resulted in predicted changes in the characteristics of snow crystals.

The project scientists, headed by Dr. Helmut K. Weickmann, director of APCL, have refined their concepts and developed their seeding technique over a period of four years, during which they conducted three field research operations.

Natural Lake Erie snowstorms generally drop the heaviest snow cover along a narrow coastal belt 10 to 15 miles wide. Dr. Weickmann and Deputy Project Director Byron Phillips believe that silver iodide seeding under certain temperature conditions can reduce the size and density of snow crystals without altering the amount of precipitation. The lighter, fluffier flakes would then be blown over a larger area, and the coastal belt would be relieved of some of the snow.

Similar localized storms occur over Lakes Ontario and Michigan, the Adriatic Sea, the Sea of Japan, and other regions where cold air flows over relatively warm water.

ERL's Research Flight Facility, Miami, Florida, flew the seeding aircraft, a highly instrumented DC-6. An extensive snow gage network downwind of the metropolitan area was operated under contract by the Cornell Aeronautical Laboratory, Buffalo.

Advisory Committee (continued)

is Senior Vice President of Mobil Oil Corporation and President of Mobil Research and Development Corporation.

—Dr. John P. Craven, Dean of the University of Hawaii, and a specialist in marine engineering who has worked with several U.S. Navy development projects and served on an interagency engineering committee whose recommendations led to the establishment of the National Data Buoy Project.

—Dr. Francis S. Johnson, Acting President of the University of Texas at Dallas. A meteorologist also expert in the space sciences and solar-terrestrial relations, Dr. Johnson is a member of the American Geophysical Union's Section on Solar Planetary Sciences and Chairman of the U.S. National Committee for the International Union of Radio Sciences (URSI).

—Dr. Ralph A. MacMullan, a zoologist, who heads the Department of Natural Resources for the State of Michigan.

—Mark Morton, Vice President and Group Executive of the Aerospace Group (Valley Forge) of General Electric Company, who previously served with the U.S. Naval Air Development Center.

—John J. Royal, Secretary-Treasurer of the Fishermen and Allied Workers Union, and a member of the Industry Advisory Committee of the U.S. Section of the Inter-American Tropical Tuna Commission.

—Dr. Julius A. Stratton, Chairman of the Board of the Ford Foundation, who served as chairman of the Commission on Marine Science, Engineering and Resources. The Commission's 1969 report, "Our Nation and the Sea," recommended the formation of the National Oceanic and Atmospheric Administration.

Those named to one-year terms on NACOA include university administrators, labor officials, an editor, a member of the Alaska State Legislature, the former Oceanographer of the Navy, and the former Assistant Secretary of Commerce for Science and Technology.

These appointees are:

—Dr. Werner A. Baum, a former Deputy Administrator of the Environmental Science Services Administration and now President of the University of Rhode Island.

—Dr. John C. Calhoun, President of Texas A & M University, formerly chairman of the National Academy of Sciences Ocean Affairs Board and of the Office of Science and Technology's Panel on Oil Spills.

—Gilbert M. Grosvenor, Editor and Vice President of the National Geographic Society. Mr. Grosvenor is Trustee of the New York Zoological Society and the African Wildlife Leadership Foundation, and Chairman of the Department of Interior's Alaska Parks and Monuments Advisory Committee.

—O. William Moody, Jr., Administrator of the AFL-CIO Maritime Trades Department; Vice President of the AFL-CIO Seafarers International Union, and Secretary-Treasurer of the Conference of Transportation Trades. As Administrator of the Maritime Trades Department, which involves 42 unions with more than 7½ million members, Mr. Moody is concerned with all areas of maritime activity, including fisheries, inland boat operations, and oceangoing transportation.

—Dr. Verner E. Suomi, prominent scientific author and holder of several patents on meteorological instruments, is Director of the Space Science and Engineering Center at the University of Wisconsin.

—Dr. Edward Wenk, Jr., Professor of Engineering and Public Affairs at the University of Washington's Aerospace Research Laboratory. He has served as technical assistant to the President's Science Advisor and to the Director of the Office of Science and Technology, and as executive secretary to the Federal Council on Science and Technology.

—Clement Tillion, member and house minority whip of the Alaskan State Legislature. A commercial fisherman, Mr. Tillion operates a pilot boat service in Alaska and serves as official advisor to the International North Pacific Fisheries Commission.

—Dr. Myron Tribus, former Assistant Secretary of Commerce for Science and Technology and now Vice President of the Xerox Corporation. Before assuming the Commerce Department post, Dr. Tribus had been Dean of the Thayer School of Engineering at Dartmouth College.

—Rear Admiral Odale D. Waters, Jr., USN (Retired), who was Oceanographer of the Navy at the time of his retirement in 1970, and is now affiliated with the Department of Oceanography at the Florida Institute of Technology. Admiral Waters was responsible for reorganizing the Navy's efforts in the oceanographic area and arranged for the Navy's oceanographic data to be made available to the civilian community.

Radio Beam From Colorado Transmitter Creates Giant Heat Bubbles in Ionosphere

Commerce Department scientists are creating immense, invisible, short-lived bubbles in the upper atmosphere in a new kind of investigation made possible by an advanced radio transmitter.

The heated bubbles are formed in seconds at altitudes up to 200 miles by the action of a 100-million-watt radio beam.

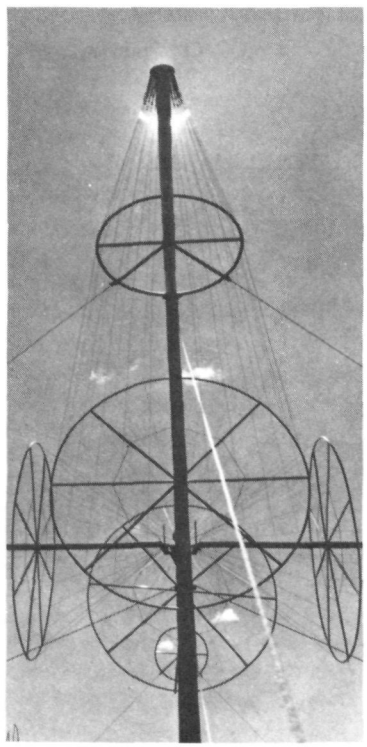
They grow to their full 50-to-100-mile size in about 20 minutes under the influence of geomagnetic forces. Composed of the electrified gas of the ionosphere, the bubbles elongate upward and downward under constriction of "tubes of force" that are generated and shaped by the earth's magnetic field.

Within minutes or hours, depending on time of day and conditions in the high-level environment, the modified region of the ionosphere rebounds to its natural state.

Observations of these effects on the upper atmosphere should lead to better understanding of the ionosphere, to improvements in long-distance radio communications, and to the advancement of plasma physics, a science that has such potential applications as power production by nuclear fusion and magnetohydrodynamics.

Results of the first year of research were reported in the journal Science by two Commerce Department scientists—Dr. William F. Utlaut, deputy director of the Institute for Telecommunications Sciences, Office of Telecommunications; and Dr. Robert Cohen, consultant to NOAA's Aeronomy Laboratory.

A new transmitter located at Platteville, Colorado, 40 miles east of Boulder, comprises a 360-foot, nine-element circular array of antennas, with an additional element in the center for beam focusing.



Circular array of antennas.

It is capable of projecting effectively a 100-megawatt radio beam that is tunable between 5 and 10 megahertz, the usual range of ionospheric penetration frequencies.

The intense beam is transmitted straight up at very close to the penetration frequency—the frequency at which a radio wave passes completely through the ionosphere. The purpose is to deposit a maximum of radio energy in the ionosphere. The closer the transmitted beam approaches the penetration frequency, the higher it reaches before being bent back to earth, the more it is slowed down, the longer it remains in the ionosphere, and the more its energy is absorbed. Within about 20 seconds, electrons in the ionosphere are heated, raising their temperatures by as much as 35 percent. The heat bubble expands more slowly, but in 20 minutes or so, its dimensions may grow to 50 or 100 miles.

A major surprise in the experiment was the artificial creation of a natural phenomenon known as Spread F—"F" referring to the upper layer of the radio-reflecting region of the ionosphere and "Spread" describing the patchy patterns of reflected signals. Under certain natural and as yet unexplained conditions, F-region echoes become diffuse, suggesting instabilities in the ionospheric plasma. If they do appear, it is almost always at night, generally after midnight. No one had predicted that the Platteville transmitter was capable of generating this Spread F, but it occurred repeatedly, in daytime as well as at night.

NOS Maps Boston Harbor Circulation

Silvery aluminum powder was dropped from aircraft and red dye spread from launches in and around Boston Harbor to obtain data which will enable authorities to reduce and control pollution in the Boston Harbor area. The two-week program was conducted in October by the National Ocean Survey, the National Aeronautics and Space Administration, and the Massachusetts Institute of Technology.

Both the red dye and the aluminum powder are harmless to shellfish, other seafood, and to water craft, dissipate after use, and are not pollutants. Measurement of their dispersion, and other data taken in the program, will result in a detailed analysis of the water, including temperature, salt content, density and the speed and direction of the currents.

Aerial photographs and special techniques were used for tracing the tidal currents with red fluorescent dye and the aluminum powder. The NOS furnished a tidal current survey vessel, the FERREL; a hydrographic survey ship, the PEIRCE; and an aerial photographic mission. NASA contributed a specially instrumented aircraft from the Houston Manned Spacecraft Center. MIT provided the vessel R. R. SHROCK and three small boats manned by graduate students. Several leased aircraft also were used.

Nicholson Heads Marine Technology

William M. Nicholson, who retired this year as a Captain in the U.S. Navy, has been appointed Associate Director of the National Ocean Survey for Marine Technology.

In his most recent Navy post, Mr. Nicholson was manager of the Deep Submergence Systems Project, responsible for the development of submarine escape and rescue systems for 5000-foot depths and of search and recovery systems for 20,000-foot depths. Previously, he had been Director of Ship Design with the Naval Ship Engineering Center, responsible for all conceptual design of ships.

At NOAA, Mr. Nicholson heads the Office of Marine Technology, established recently as the focus for the agency's efforts in testing, evaluating, and calibrating sensing systems for ocean use. He will direct the activities of the National Ocean Survey's Engineering Development Division, National Oceanographic Instrumentation Center, National Data Buoy Center, and the Marine Data Systems Project.

A native of Napa, California, Mr. Nicholson attended the California Institute of Technology and the U. S. Naval Academy, from which he graduated in 1941. He later attended the Navy Postgraduate School at Annapolis and the Massachusetts Institute of Technology, where he earned a master's degree in naval architecture and marine engineering in 1948. During his 30-year Navy career, he has served at the Bureau of Ships in Washington, D.C.; at Naval Shipyards at Mare Island, Calif., Boston, Mass., and Bremerton, Wash.; aboard the aircraft carrier USS PHILIPPINE SEA; at the U.S. Navy Postgraduate School in Monterey, Calif.; and as professor of naval construction at MIT.

NWS Develops Storm Surge Forecast Method

The Techniques Development Laboratory of the National Weather Service's Systems Development Office has developed an automated technique for forecasting extratropical storm surges along the northeast coast of the United States.

The storm surge is the abnormal rise of water level above astronomical tide level caused by strong winds associated with extratropical storms over nearshore areas. Surges from this type of storm damage parts of the northeast coast on the average about six times each winter season.

Forecast equations have been derived for the following eight locations: Portland, Me.; Boston, Mass.; Newport, R.I.; New York, N.Y.; Atlantic City, N.J.; Breakwater Harbor, Del.; Baltimore, Md.; and Norfolk, Va. These equations were derived using data from 68 storm surges which occurred from 1956 through 1969. Input data to these forecast equations are sea-level pressure values as forecast by the primitive equation model of the National Meteorological Center.

The forecast method was put into operation on October 27 on an experimental basis. Forecasts are transmitted to east coast stations via teletypewriter and consist of values projected out to 36 hours at six-hour intervals. These projections are used by NWS marine forecasters as guidance in preparing the actual storm surge predictions.

72-Hour Forecasts Assist Shippers

The Techniques Development Laboratory of the National Weather Service Systems Development Office has extended its automated forecasts of surface temperature at 131 cities by an additional twelve hours on an operational basis, once a day. The existing morning teletypewriter bulletin now contains a 72-hour forecast of the maximum temperature expected the day after tomorrow, in addition to the customary 24 to 60-hour projections. The new forecast product is based on extended runs of the National Meteorological Center's primitive equation model and should be helpful in satisfying a long-standing requirement for temperature forecasts for shippers.

Project Stormfury Seeds Rainsector in Hurricane Ginger

Hurricane Ginger was the target of Project Stormfury—the joint Commerce/Department of Defense hurricane modification effort—on September 26 and 28, 1971.

The rainsector experiment was performed for the first time and, although the storm did not offer great potential for modification, the seedings did change the structure of the clouds in the seeded area.

The objective of the Project's rainsector experiment, in which a number of rainbands flowing toward the hurricane's center are seeded, is to disperse the storm's energy before it can become concentrated in one area, such as the narrow band around the eye.

In a preliminary report on the modification experiments, Dr. R. Cecil Gentry, Project Director, said: "it is encouraging that on a day when a large number of clouds were seeded (the 28th), the winds did decrease in the mean. Evidence at present is insufficient to justify saying that the seeding caused the decrease. On the first day there was an increase in wind speed, but the evidence is quite strong that natural forces caused the increase."

Instruments Detect Record Creep Event

The largest creep event ever recorded has been detected by a dense network of instruments set up by NOAA along a branch of California's San Andreas fault.

Observed July 17, 1971, at four instrument sites along the Hayward-Calaveras fault in and to the north of Hollister, Calif., the record event produced maximum fault movement of nine millimeters (slightly more than a third of an inch), a large amount of motion in view of the annual average fault creep in Hollister of about 10 millimeters.

Creep is a non-seismic motion along a fault, a zone of weakness (or fracture zone) in the earth's crust. Like the fault movement associated with earthquakes, creep appears to be a break-and-slip process, occurring in episodes, or "steps," or stress-relieving movement.

The July 17 event was the first whose rupture length—about six kilometers, or about three and three-quarter miles—was directly measured, the result of installing a relatively dense network of instruments over the past several years. The event occurred as one of a cluster of fault creep motions observed during July and early August by ERL's Earthquake Mechanism Laboratory.

NOAA Honors Individuals and Units At December Awards Night Program

Seven NOAA Awards, thirty-three Unit Citations for Special Achievement, and two NOAA Equal Employment Opportunity Awards were presented at the NOAA Awards Night Dinner-Dance in Silver Spring, Md., on December 3.

The seven winners of the 1971 NOAA Awards for unusually significant achievements were Bertha V. Fontaine, Gerald L. Shak, Dayton L. Alverson, Eldon E. Ferguson, Leonard M. Murphy, Captain Lawrence W. Swanson, NOAA (ret.), and Silvio G. Simplicio. For their special contributions to NOAA programs, each received one thousand dollars and a plaque.

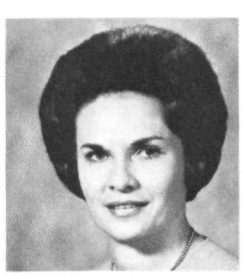
The Award for Public Service, recognizing unusually significant contributions to the quality and effectiveness of NOAA's public service programs, was given to Bertha V. Fontaine, a home economist with the National Marine Fisheries Service's Market Research and Services Division, Pascagoula, Miss. and to Gerald L. Shak, User Services Representative at National Weather Service Eastern Region Headquarters, Garden City, N.Y.

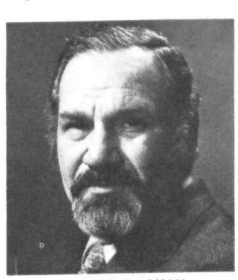
The two winners of the NOAA Award for Scientific Research and Achievement, for unusually significant contributions to scientific research and development and for outstanding contributions to scientific literature were: Dr. Dayton L. Alverson, Acting Director of the National Marine Fisheries Service North Pacific Fisheries Research Center, Seattle, Wash., and Dr. Eldon E. Ferguson, Chief of the Atmospheric Collision Processes Program in the Aeronomy Laboratory, Environmental Research Laboratories, Boulder, Colo.

Leonard M. Murphy of the Environmental Research Laboratories' Earth Sciences Laboratories was the 1971 recipient of the Engineering and Applications Development Award, for unusually significant contributions to the operating or research programs of NOAA through achievements in engineering, applied technology, or systems and equipment development.

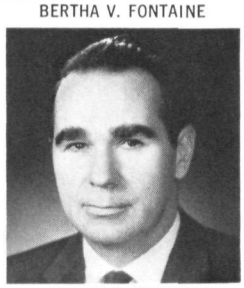
The Program Administration and Management Award is given for unusually significant contributions to the efficiency and quality of NOAA's management and administrative activities. Receiving the 1971 awards in this category were Captain Lawrence W. Swanson, NOAA (ret.), Project Manager of the National Ocean Survey's Geodetic Satellite Program, and Silvio G. Simplicio, Director of the National Weather Service's Eastern Region, Garden City, N.Y.

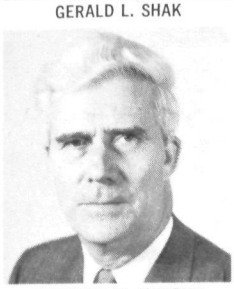
Unit Citations recognizing groups of employees who have made substantive contributions to NOAA programs or objectives, were awarded to the following:

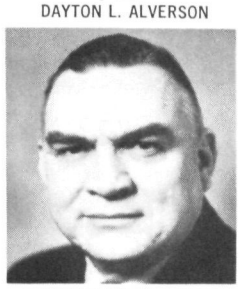

BERTHA V. FONTAINE


GERALD L. SHAK

DAYTON L. ALVERSON


ELDON E. FERGUSON


LEONARD M. MURPHY


CAPT. L. W. SWANSON

SILVIO G. SIMPLICIO

ALONZO SMITH

HAROLD E. MACKEL

NOAA Ships RUDE and HECK; Seismological Field Survey, Environmental Research Laboratories, San Francisco, Calif.; Special Projects Party, Environmental Research Laboratories, Las Vegas, Nev.; Albuquerque Seismological Center, Environmental Research Laboratories; Atmospheric Acoustics Program Area, Environmental Research Laboratories, Boulder, Colo.; Earthquake Mechanism Laboratory, Environmental Research Laboratories, San Francisco, Calif.; ISIS (International Satellites for Ionospheric Studies) Engineering and Operations Group, Environmental Research Laboratories, Boulder, Colo.; Project HANDS (High Altitude Nuclear Detection Studies), Environmental Research Laboratories, Boulder, Colo.;

Warren E. Ames, Benjamin G. Patten, John R. Hughes, and George F. Slusser, National Marine Fisheries Service, Seattle, Wash.;

Marine Geophysics Group, Environmental Data Service, National Geophysical Data Center;

William Thomas, Jr., Franklin C. Lewis, Robert C. Lavoie, and Albert G. Tillery, National Environmental Satellite Service;

Weather Service Forecast Office, San Juan, P.R.; Weather Service Forecast Office, Great Falls, Mont.; Weather Service Forecast Office, Cleveland, O.; Weather Service Office, Waterloo, Iowa; Weather Service Office, La Crosse, Wisc.; Weather Service Office, Madison, Wisc.; Weather Service Office, Dodge City, Kans.; Weather Service Office, Goodland, Kans.; Weather Service Office, Concordia, Kans.; Weather Service Office, Grand Island, Nebr.; Weather Service Office, Lincoln, Nebr.; Weather Service Office, Topeka, Kans.; Weather Service Office, Omaha, Nebr.; Weather Service Office, Fairbanks, Alaska; Weather Service Office, Hilo, Hawaii; Weather Service Office, Allentown, Pa.; Weather Service Office, Wilkes-Barre-Scranton, Pa.; Weather Service Office, Jackson, Miss.; Weather Service Office, Corpus Christi, Tex.; Weather Service Meteorological Observatory, Dayton, O.; River Forecast Center, Sacramento, Calif.; and National Weather Service agricultural forecasters, Southern California and Arizona.

NOAA Equal Employment Opportunity Awards for 1971 were presented to Alonzo Smith, Development Division, National Weather Service; and Harold E. Mackel, Career Development Branch, NOAA Personnel Division.

all in the family

PERSONNEL NOTES

Dr. Edward D. Diemer, former Chief of the Anchorage Regional Headquarters Scientific Services Division, became Meteorologist in Charge of the Anchorage (Alaska) NWS Forecast Office, succeeding G. Philip Weber, retired.

Commander Peter A. Morrill, Deputy Director of the National Data Buoy Center, has been assigned as Acting Director of the Center.

Dr. Sigmund Fritz, Chief Space Scientist at the National Environmental Satellite Service is the new President of the International Association of Meteorology and Atmospheric Physics (IAMAP).

Dr. Helmut Weickmann, director of the Environmental Research Laboratories' Atmospheric Physics and Chemistry Laboratory (APCL) has been reelected president of the IAMAP International Commission on Cloud Physics.

Dr. Leroy R. Alldredge, director of the Environmental Research Laboratories' Earth Sciences Laboratories, has been reelected general secretary of the International Association for Geomagnetism and Aeronomy.

Harold J. Welch, retired University of Michigan professor and an authority on computer technology, has been appointed as a research geodesist in the NOS' National Geodetic Survey.

Dr. Richard E. Felch and **Dale E. Phinney,** have joined the Environmental Data Service Laboratory for Environmental Research as meteorologists. Dr. Felch was formerly an extension agronomist for climatology at Iowa State University. Mr. Phinney has been a research programmer at Purdue since receiving his master's in meteorology and air pollution there this year.

Jo Ann Joselyn, a physicist in ERL's Space Environment Laboratory in Boulder, has been selected to be listed in the 1971 edition of Outstanding Young Women of America.

Perry M. Landgren, former meteorologist in charge at the Knoxville, Tenn., Weather Service Office since 1963, is the new meteorologist in charge at El Paso, Tex.

William E. Jones, Chief of the Presentation Arts Section in NOAA's Visual Services Branch, received a Commerce Bronze Medal for "development and management of programs in the fields of cartography and scientific illustrating."

George W. James, a former carpenter-leader in ERL's Boxing and Packing Unit, has been awarded a Bronze Medal for his "unsurpassed record over the past 15 years of transmitting equipment to remote sites and having it arrive intact."

Dr. Earl E. Gossard has been appointed Chief of the Geoacoustics Research Program area of the Environmental Research Laboratories' Wave Propagation Laboratory. From his office in Boulder, Colo., he will lead both the Boulder and the Washington, D.C., components of Geoacoustics group.

Commander Richard Alderman has been assigned to the Office of Marine Resources as the Acting Executive Secretary for the Interagency Committee for Marine Science and Engineering.

Floyd S. Anders, Jr., formerly chief of the National Marine Fisheries Service Office of Resource Research's technical advisory division, has been named Deputy Regional Director of the NMFS Southwest region, headquartered in Terminal Island, California.

Commander Archibald J. Patrick is the new Executive Officer of the NOAA Ship DISCOVERER.

Lt. Cdr. Richard H. Allbritton, who was attached to the Atlantic Oceanographic and Meteorological Laboratories in Miami, Fla., has been named to succeed Cdr. Patrick as the DISCOVERER's Operation Officer.

Norman L. Pease has been named NMFS regional fisheries attache (Africa). His headquarters post is in Abidjan, Ivory Coast.

Salvatore DiPalma, who formerly served at the Abidjan post is now NMFS regional fisheries attache (Europe), with headquarters in Copenhagen, Denmark.

Dr. Martin A. Kjelson, recently appointed to the staff of the NMFS Atlantic Coastal Fisheries Center on Pivers Island, N.C., will head a project on the ecology of marine fishes, particularly those in nearby estuaries and sounds.

Rue E. Rush, Meteorologist in Charge of the Weather Service Forecast Office in Raleigh, N.C., has been appointed to the North Carolina Department of Public Instruction Advisory Committee on Earth Science.

Dr. C. Gordon Little has returned as director of ERL's Wave Propagation Laboratory from a nine-month research assignment in Australia, where he worked with Dr. J. B. Priestly at the Commonwealth Scientific Industrial Research Organization (CSIRO) in the area of mesoscale meteorological processes.

Captain Eugene A. Taylor has been named Deputy Associate Director of the National Ocean Survey's new Office of Fleet Operations, established to direct NOAA's 46-ship fleet.

Milo J. Andre is the new Regional Climatologist at National Weather Service Southern Region Headquarters in Forth Worth, Tex.

Lt. (j.g.) Roger DeVivo, manager and analyst for the NWS Facilities Engineering Branch's Facilities Management Reporting System (FMRS), has received a Special Achievement Award for his improvements and revisions to that system during the past year.

Walter Kirkness, acting associate director for resource management of the National Marine Fisheries Service, has been appointed U.S. commissioner on the North Pacific Fur Seal Commission.

William L. Turner, former weather service specialist at Worcester, Mass., has been appointed meteorologist in charge of the Chatham, Mass. Weather Service Meteorological Observatory.

Eldon V. Jetton, Meteorologist in Charge at El Paso, Tex., since 1968, has been named MIC at the National Weather Service Forecast Office in Little Rock, Ark.

Joseph Vederman, for the past 11 years Meteorologist in Charge of the Weather Service Forecast Office in Honolulu, is the new MIC at the Los Angeles Weather Service Forecast Office. He replaces George W. Kalstrom, who retired on May 31.

Edward M. Carlstead, Chief of the Scientific Services Division in the National Weather Service's Pacific Region Headquarters in Honolulu for the last six years, has been named Meteorologist in Charge of the NWS Forecast Office at Honolulu.

Richard B. Neave, who has been fire weather supervisor at Albany, N.Y., for the past five years, has been named Meteorologist in Charge at the Syracuse, N.Y., Weather Service Office.

Dr. Robert L. Edwards and Richard C. Hennemuth have been named Director and Deputy Director, respectively, of the North Atlantic Fisheries Research Center, headquartered at Woods Hole, Mass. Dr. Edwards was formerly NMFS acting associate director for resource research, and Mr. Hennemuth was director of the NMFS Biometrics Institute at Woods Hole.

Eugene Bollay Appointed to Lead Modification Work

Eugene Bollay, past president (1970) of the American Meteorological Society, has been named to NOAA's new post of program director for weather modification. He was formerly director of meteorological sciences at E.G.&G., Inc., and active in its stratospheric research program for the Los Alamos Scientific Laboratories, and its Albuquerque Office's environmental science and weather modification program.

Stationed at NOAA's Environmental Research Laboratories in Boulder, Colo., Mr. Bollay is the focal point for all weather control research efforts within ERL, and for NOAA's participation in meteorological research by universities and government agencies in this country and abroad. He also has line management responsibility for ERL's Research Flight Facility and Experimental Meteorological Laboratory in Miami.

Mr. Bollay, who was born in Stuttgart, Germany, became a naturalized U.S. citizen in 1928. He earned a B.S. at Northwestern University in 1935 and an M.S. from the California Institute of Technology in 1936.

In 1966 he received the American Meteorological Society Industrial Meteorology Award and, in 1970, an Air Weather Service Special Award.

NOAA Scientists Chosen to Analyze ERTS, Skylab Data

Four NOAA scientists are among the group selected by the National Aeronautics and Space Administration to analyze data gathered by the first Earth Resources Technology Satellite (ERTS-A) and by the Earth Resources Experiment Package (EREP) aboard the manned Skylab. Dr. P. M. Kuhn of the Atmospheric Physics and Chemistry Laboratory, Boulder, Colo., will conduct a concentrated atmospheric radiation project; George A. Maul of the Atlantic Oceanographic and Meteorological Laboratories, Miami, will experiment with remote sensing of ocean currents; Morton Keller of the National Ocean Survey will examine the feasibility of EREP photography for coastal zone mapping; and William H. Stevenson of the National Marine Fisheries Service Aerospace Remote Sensing Program at Bay St. Louis, Miss., will relate oceanographic data to fish resource abundance.

Florida Project Increased Rain

Cloud seeding experiments in Florida this spring increased rainfall by an estimated 100,000 acre-feet, Dr. Joanne Simpson and Dr. William L. Woodley of the Experimental Meteorology Laboratory reported in December.

They presented their report on the NOAA-State of Florida seeding program to the Florida Governor's Environmental Coordination Council and to the AMS Conference on Hurricanes and Tropical Meteorology.

The project was conducted by NOAA, in cooperation with the Central and Southern Florida Flood Control District. Earlier in the year, Governor Reubin Askew had asked NOAA's help in attempting to relieve the worst drought in the state's history.

Cumulus clouds were seeded with silver iodide on 14 days between April 1 and May 31. The seeding was carried out by a DC-6 from NOAA's Research Flight Facility, accompanied on a few missions by the Research Flight Facility's B-57 which seeded simultaneously.

"The total calculated rainfall from seeded clouds for the whole experiment was about 180,000 acre-feet," Drs. Simpson and Woodley said. "The estimated rainfall increase due to seeding was a little above 100,000 acre-feet. This is almost certainly an underestimate."

"While the water volume attributed to seeding was a small fraction of the existing shortage," they pointed out, "the benefit-to-cost ratio of the program was very high indeed. The final best cost estimate was $165,000 of which $40,000 was expended by the Central and Southern Florida Flood Control District, and $125,000 by NOAA. If the water cost is assumed to be $50 per acre-foot (from the municipal water systems in south Florida), the ratio of benefit to cost is 32. If a water cost of $108 per acre foot is used (overhead sprinkler irrigation), the ratio becomes 68. Some of the seeded rainfall quenched Everglades fires and hence may have been much more valuable than these numbers indicate."

Although cloud seeding does not produce enough rain to break a drought, the results of the experiment led Drs. Simpson and Woodley to conclude that dynamic seeding can probably provide worthwhile local drought mitigation in Florida, but that its real efficacy remains to be established by randomized research.

Commerce Awards NOAA Employees Six Gold, Fifteen Silver Medals

Six Gold Medals and fifteen Silver Medals were presented to NOAA employees in the Commerce Department's 23rd Annual honor awards program, October 28.

Recipients of the Gold Medal, the highest honor conferred by the Department, were:

Harold L. Crutcher, scientific advisor, National Climatic Center, EDS, Asheville, N.C., for major scientific contributions to national defense, the space program, NOAA, and the Department of Commerce programs and the international scientific community. Since 1951, Dr. Crutcher has provided scientific leadership for the U.S. Navy's Marine Climatic Atlas of the World program, providing military planners and scientists with the most comprehensive marine atlas ever developed. Dr. Crutcher has subsequently developed an upper-air climatic atlas series for the Northern Hemisphere, and was the catalyst in the development of the first comprehensive upper-air climatic atlas for the Southern Hemisphere.

Robert S. Dietz, research oceanographer, ERL's Atlantic Oceanographic and Meteorological Laboratories, Miami, Fla., for two major discoveries which have significantly altered the development of the earth sciences. He was one of the first to point out the importance of research on terrestrial meteor craters and led the way in their identification and establishing their meteoric origin. His studies explaining how the idea of continental drift could be integrated with the history of the ocean floor have led to the development of one of the most important concepts in geophysics today—that of sea-floor spreading.

Roy L. Fox, retired Director of the National Weather Service's Central Region, Kansas City, Mo., for developing and managing weather services of paramount importance to the safety of residents of the severe-weather-prone Midwest. Through exceptional initiative, highly imaginative thinking, and particularly adept management ability, Mr. Fox developed and maintained a high state of readiness for warning of severe storms among the Weather Service Offices and the communities they serve.

Raymond L. Joiner, digital computer systems analyst, National Climatic Center, EDS, Asheville, N.C., for his efforts in extracting the maximum possible scientific intelligence from raw data collected during the Barbados Oceanographic and Meteorological Experiment, achieving results whose scientific sophistication had appeared to be beyond the capability of the original instrumentation and existing technology.

Robert A. McCormick, Director, ERL's Air Resources Laboratory, Raleigh, N.C., for outstanding contributions of major significance in relating meteorology to human problems through his outstanding leadership in administration in the field of air pollution meteorology. His leadership in national and international programs for modeling the atmosphere over urban areas has contributed to knowledge of pollutant dilution. He has directed attention to problems of increasing levels of pollution on a global scale. His contributions to science in this area and the field of air pollution have been noteworthy.

Donald F. Moore, NOAA Assistant Administrator for Policy and Plans, for outstanding leadership which has been a critical factor in the success NOAA has had in converting from ESSA into the nation's major center for civil strength in the oceans, atmosphere, and solid earth geophysics. He was cited particularly for his distinguished leadership in preparing the National Oceanic and Atmospheric Administration's first program plans for fiscal years 1972 and 1973 within a period of less than six months.

Silver Medals were awarded to:

Francis J. Balint, Chief, NOAA Management Systems Division;

Robert O. Cole, Deputy Chief, Basic Weather Forecast Branch, Analysis and Forecast Division, National Weather Service's National Meteorological Center, Suitland, Md.;

Joseph F. Dracup, Chief, Adjustment Section, Geodesy Division, National Ocean Survey;

Reynold A. Fredin, Director, Biometrics Institute, Biological Laboratory, National Marine Fisheries Service, Seattle, Wash.;

Otha Fuller, Jr., Chief, Operations Branch, Data Automation Division, National Weather Service's National Meteorological Center, Suitland, Md.;

Harold L. Goodwin, Deputy Director, Office of Sea Grant;

Elbert C. Hill, Jr., meteorologist, National Hurricane Center, National Weather Service, Miami, Fla.;

Charles E. Kincaid, staff assistant for administration, EDS National Oceanographic Data Center;

Captain William E. Randall, NOAA Corps, Office of the Administrator;

Henry Rockwood, Chief, Data Acquisition Branch, National Weather Service's Eastern Region, Garden City, N.Y.;

J. Malcolm Symons, Chief, Tides and Currents Branch, Oceanography Division, National Ocean Survey;

Robert G. Twa, meteorological technician, National Weather Service, Muskegon, Mich.;

Arthur W. Youmans, Chief, Operations Branch, Overseas Operations Division, National Weather Service;

John R. Hope, hurricane specialist, and Charles J. Neumann, research meteorologist, NWS National Hurricane Center, Miami, Fla.;

William J. Monteith, supervisory civil engineer, and Herman Ebel, survey boat operator, Lake Survey Center, National Ocean Survey, Detroit, Mich.

Geodetic Survey Measures Height Of Capitol Hill

For the first time in almost half a century, surveyors measured the elevation of Capitol Hill—the site of the U.S. Capitol. These measurements will reveal whether the 8,909,200-pound Capitol structure has caused the site to sink since its first measurement in 1884.

The measurements were conducted by the NOS-National Geodetic Survey, whose predecessor agency made the first measurements 87 years ago and placed a five-inch-square bronze plate inscribed "CAPITOL BENCH MARK US COAST AND GEODETIC SURVEY 1884" under the first window of the southeast corner of the Capitol in the Senate wing.

The elevation was measured subsequently by the C&GS in 1914 and 1923, and by the District of Columbia Bureau of Public Buildings and Public Parks in 1926, when the heights determined were: House side, 87.103 feet; main (East) entrance, 90.558 feet; and Senate wing, 90.544 feet.

The survey was part of a larger project for the Army Corps of Engineers, whose evaluation of the Chesapeake Bay resources may lead to a plan for maintaining and enhancing the Bay environment. Three units of a 29-man NGS field party headed by Robert R. Gerrish, checked three routes within the District of Columbia which radiate from the Capitol. The routes are part of a leveling network that will connect tide gages along the shores of the Chesapeake and adjacent river estuaries.

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The current popularity of poster art gets an assist from the Fisheries Service with a chart of

Commercial and Game Fish in North Atlantic Waters

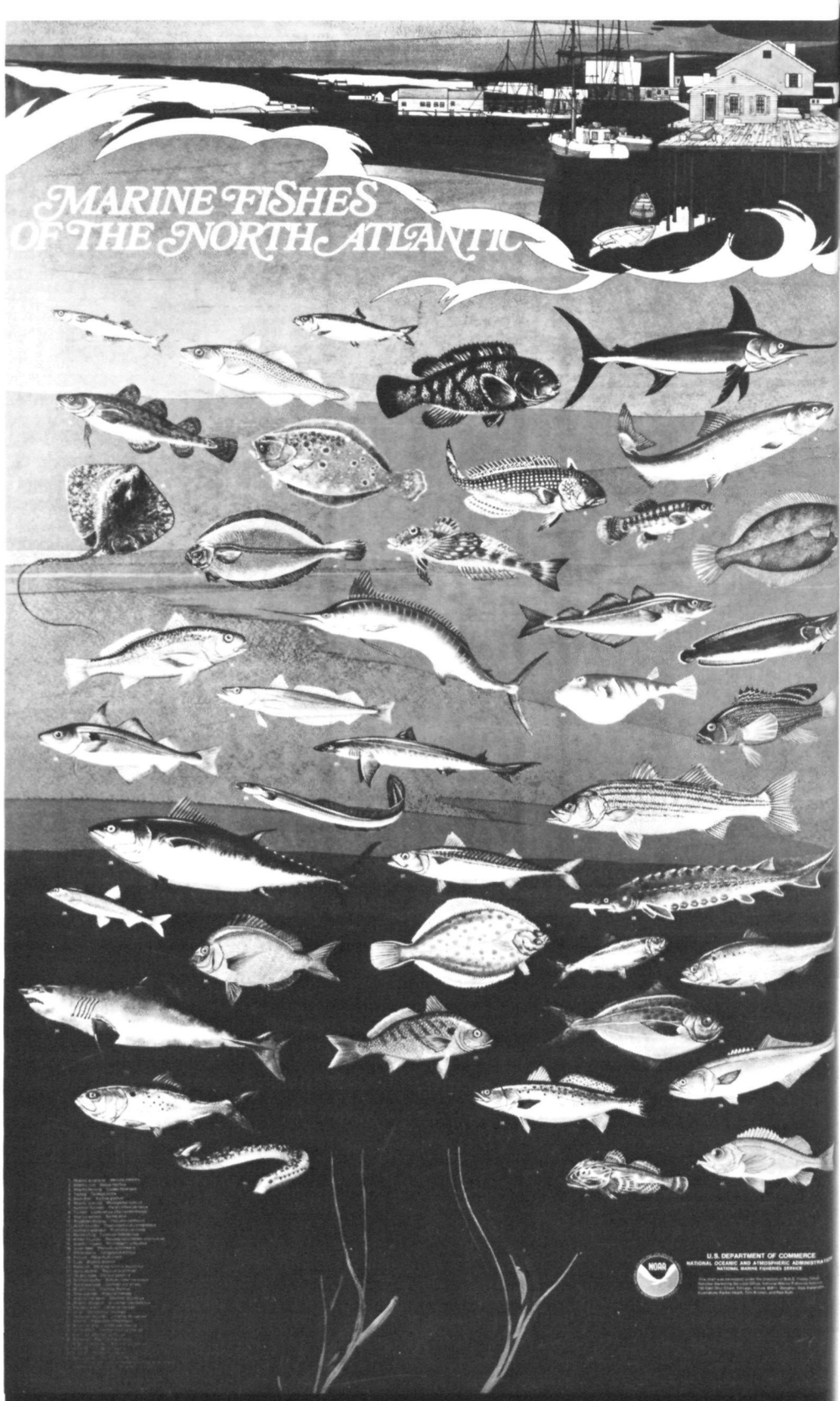
A handsome addition to the world of naturalistic art was issued recently by NOAA's National Marine Fisheries Service, in the form of a four-color poster entitled "Marine Fisheries of the North Atlantic." The montage of 42 species of commercial and game fish was introduced during FISH EXPO '71, held at Boston, Mass., in late October, and put on sale to the public soon afterward.

The project was conceived and directed by Bob Finley, chief of the NMFS National Marketing Services Office in Chicago, and the work was designed and executed by artists Wes Watanabe, Parker Heath, Tom Kronen, and Rod Ruth.

A panel of marine biologists made the representative selection of North Atlantic fish species and supplied the artists with scientifically exact specifications for the drawings. Not only are familiar species shown, such as cod, flounder, and haddock, but the chart illustrates other not so commonly known inhabitants of the North Atlantic, such as the white shark, the roughtail stingray, and the white marlin.

The 30-inch-wide by 48-inch-long fish chart with scenic decorations is printed on washable non-glare plasticized paper that hangs flat against a wall without curling. Margins are provided to allow for framing. A list of common and scientific names of the fishes appears in the lower lefthand corner.

Four additional fish charts are planned, to delineate species found in west coast waters, fishes from the South Atlantic and the Gulf of Mexico, freshwater species, and shellfish. All of the charts will be color-coordinated and similarly styled, to create a set of five attractively matched posters.



The new fish poster is available for $1.50 per copy (25 percent discount on orders over 100) through Government bookstores and the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.