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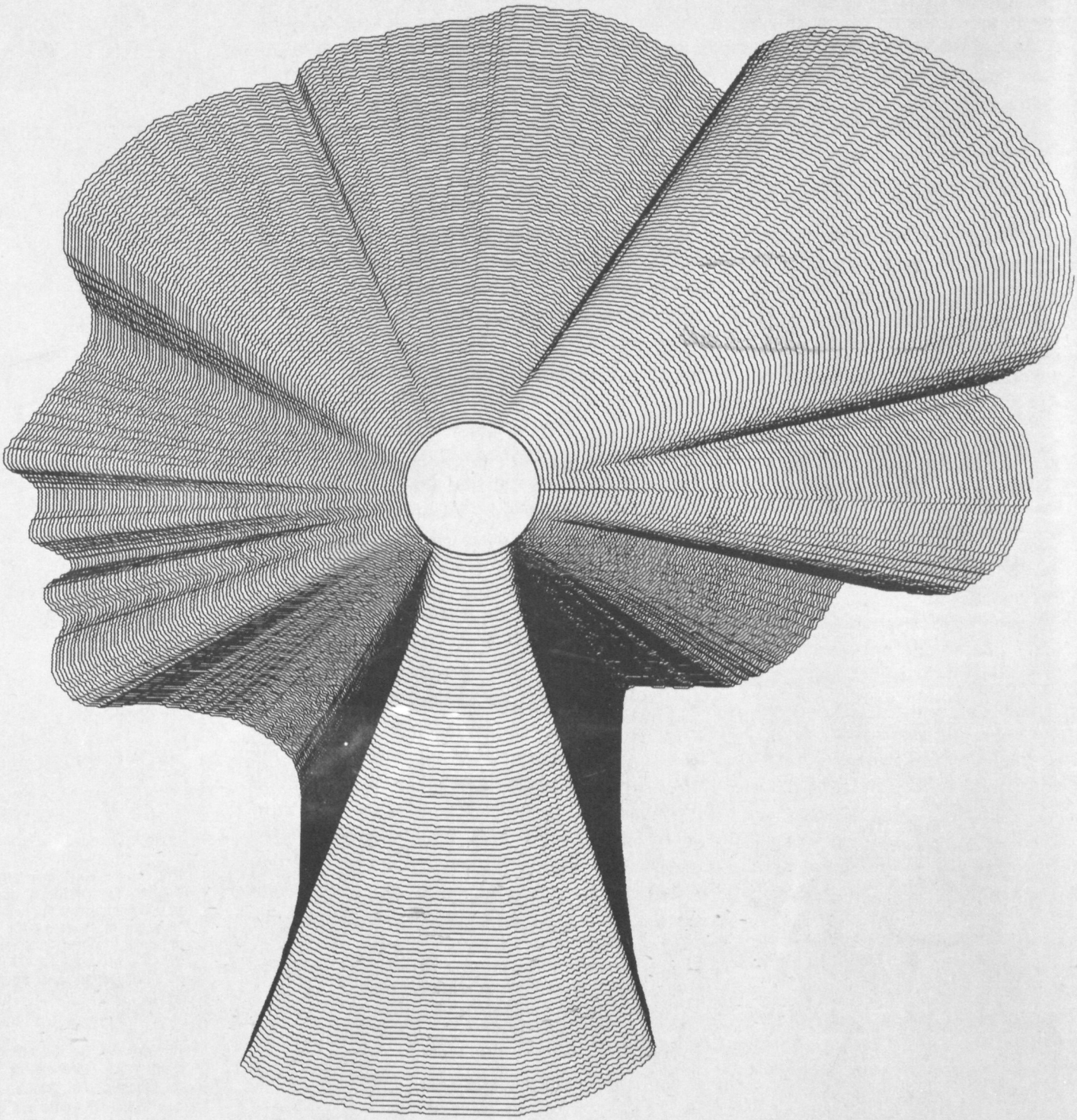
U.S. DEPARTMENT OF COMMERCE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION



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NUMBER 3

National Oceanic and Atmospheric Administration

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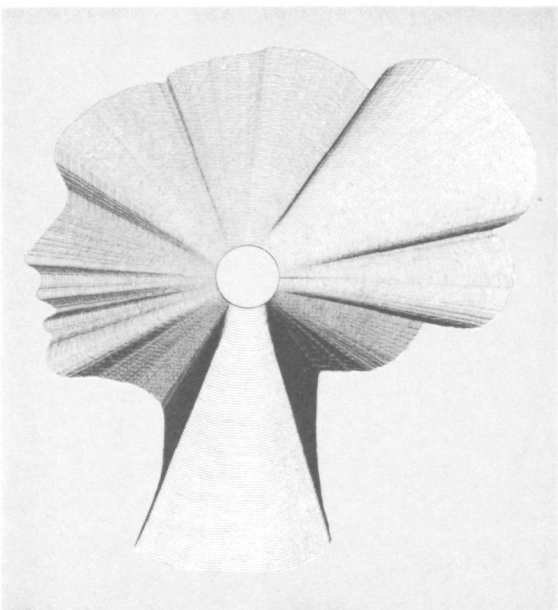
U.S. DEPARTMENT OF COMMERCE
Maurice H. Stans, Secretary

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

JULY 1971
VOLUME 1 NUMBER 3

page

3. A Message From the Administrator
4. World on a Screen
9. Putting a Name to It
12. Hurricane: Yes or No
22. A Thriving Herd
26. In Pursuit of the Plume
30. The Shirtsleeve Touch
34. When the Wind Blows
39. Our Global Air
42. What's Down Under?
46. One Week in Laguna
50. High and Low
54. Please Don't Step on the Algae
56. Bringing Up Lobster
59. Summer Coolers
62. News From NOAA



COVER

Computer graphics work for art, as well as for science. The computer supplemented the artist's imagination to produce the woman's head on the front cover and the abstract drawing on the back cover.

STANLEY B. EAMES
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A Message From the Administrator

ROBERT M. WHITE

The National Oceanic and Atmospheric Administration is nine months old.

It has been an exciting period during which the organizations from which NOAA was assembled performed magnificently in executing their tasks while undergoing major change.

NOAA's first organization—the one under which we are operating now, to all intents and purposes—was, of necessity, an interim affair. We were undertaking many diverse kinds of effort carried out by several different—and differently-operated—agencies. At the outset, several major changes were made, but they are clearly not sufficient to accommodate the nature of the NOAA mission.

NOAA must organize itself to operate efficiently, and the route to efficient operation lies in organizing around the things we do. The scope and variety of our programs is tremendous but these programs, we find, fall well within a very few broad conceptual categories.

We are concerned with resource exploration, development, management and conservation in the oceans. We are concerned with environmental monitoring, prediction and modification—and developing the capacity to exercise, ultimately, some degree of environmental control. Here environment is taken to mean the oceans, the atmosphere, and solid earth. And we are concerned with developing the science and technology required to execute these tasks.

These missions all involve several NOAA organizations in a number of different ways. For example, in the area of ocean resources the National Marine Fisheries Service, the National Ocean Survey, the National Sea Grant Program, the Environmental Research Laboratories and the Environmental Data Service, all are involved. I could extend the parallel to other areas, but this will illustrate my point: organizing to handle endeavors of this complexity cannot be done within the confines of one line agency. Every available and pertinent NOAA resource must be brought to bear on each major problem we face.

It follows, then, that we must restructure key elements of our organization. Such changes as are effected need not be considered as changeless; if something doesn't work, we shall not hesitate to change it again, or to return to an original method which proved more effective.

Let me offer you my personal assurance that two major principles will guide our reorganizational efforts.

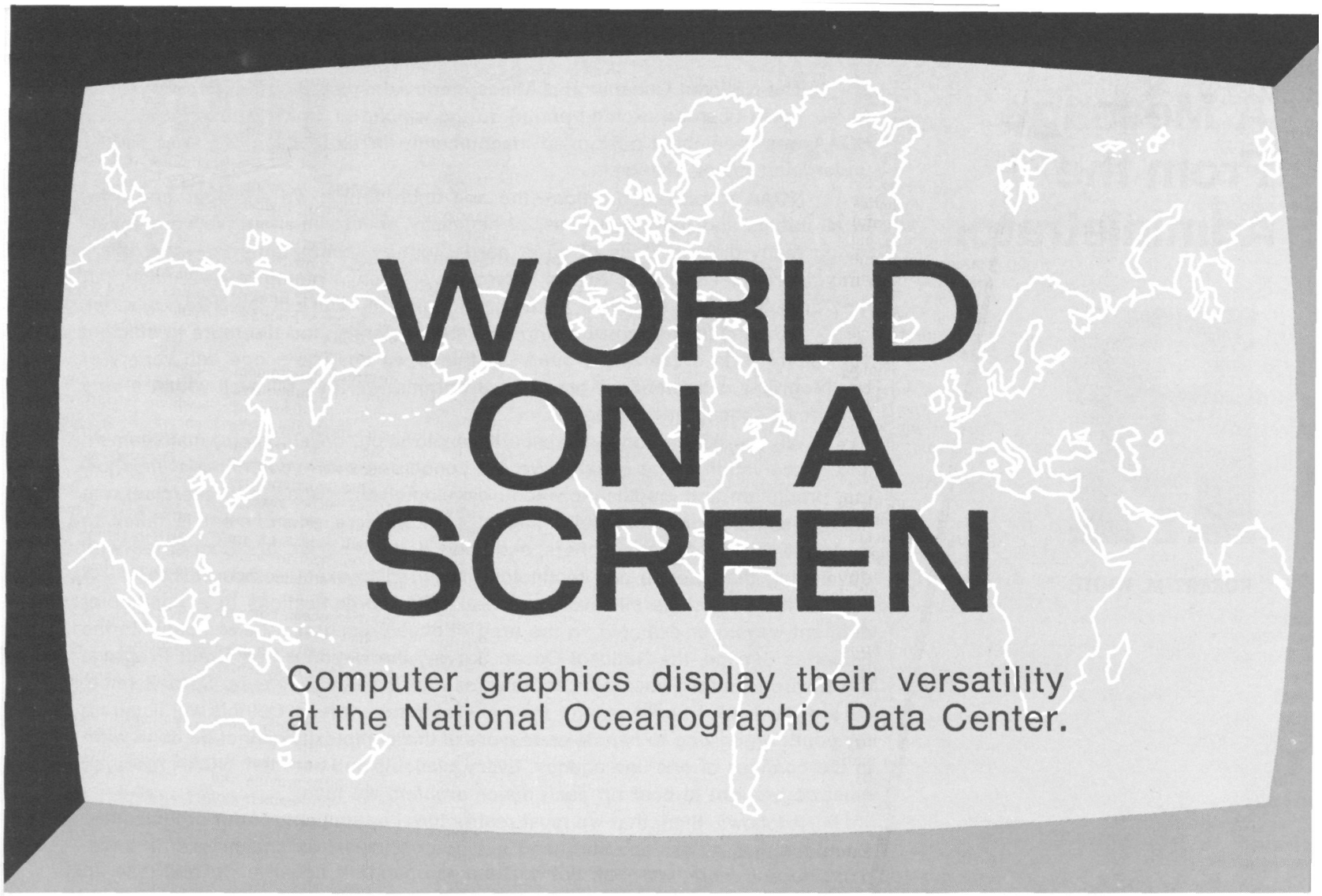
First, nobody will lose a job because of the organizational change. If anything, the new organization should offer more opportunity for achievement and career advancement than the old.

Second, dislocation will be kept to a minimum. Geographical changes will be made slowly, in an evolutionary way. Every humanitarian factor will be carefully considered.

When the winds of reorganization begin to blow, there is a natural inclination to settle back, not to take major decisions, to let well enough alone. I hope this will not happen in NOAA, and that the entire NOAA family will continue functioning as vigorously as usual. We have much to do; let us get on with it.

Meanwhile, as changes are being made, I urge not only your patience and your cooperation but your confidence that the reorganization will enable NOAA, and all of us in NOAA, to serve our Nation better. I pledge that your leadership will exert every effort to make sure that it does.

Robert M. White



WORLD ON A SCREEN

Computer graphics display their versatility at the National Oceanographic Data Center.

BY ANN WEEKS

In Washington, D.C., a young man sits at the keyboard of an instrument that resembles a combination television set and typewriter, commanding the machine to tasks that result in projections of detailed maps of portions of the world. The maps are overlaid with grids containing numbers that indicate many of the physical and chemical characteristics of marine waters.

In California, an artist produces delicately beautiful abstractions destined to grace the walls of an art gallery.

What do these two strangers have in common? The computer. Each is working in computer graphics, one of the lesser known "talents" of data-processing systems.

The young man is John O. Ward, a computer-programmer at the National Oceanographic Data Center; the artist is Grace Hertlein, established in the world of fine arts and sculpture, whose computer artwork has won renown.

Their work is widely divergent, of course, but their expressed philosophies have a subtle accord. Ward says: "People must be sitting all over the world with stacks of data, unaware of our ability to depict them, graphically and otherwise. I would like them to know about our facilities. We can draw the whole world the size of a thumbprint." Says Miss Hertlein: "The limits of the computer artistically are the limits of the artist's imagination, and the degree to which the artist accepts the computer as an aid to his creation."

The ambitious computer-graphics project now in operation at NODC was designed by John Ward to display geographical data in forms that include computer-produced maps of land and water masses of the entire world, statistical summaries, and plots and graphs of various water properties which may be superimposed on the map images. Another promising computer-graphics program, now in early developmental stages, is called the "live atlas." NODC regards its series of programs based on computer graphics as an important adjunct to the services the center offers to the oceanographic community.

In its one decade of existence, NODC has become a mainstay of the extensive oceanographic effort in this country and, to a degree, of similar foreign enterprises. As the national repository for global ocean data, the NODC gathers, interprets, processes, stores, and dispenses enormous quantities of the information so vital to man's pursuit of knowledge of the seas. It is now an arm of NOAA's Environmental Data Service.

The task set for the NODC when it was established in December 1960, was to acquire all available oceanographic data, manage them, and then develop and perfect a series of storage and retrieval systems whereby the data would be readily available to a broad audience. A pioneer in its field (the center had no true counterpart anywhere else in the world at the time), NODC carried

out its mission so well that by 1970 it was a going national concern that fulfilled more than 3,000 requests for marine data in that year.

In its first nine years of existence, NODC used leased computer facilities for its work, a procedure that was far from satisfactory from several points of view. In late 1969, however, the organization rented and installed its own "medium-scale" computer. The center had, in the vernacular of the computer world, progressed to a "third-generation" data system. (Gestation periods for computer generations are considerably shorter than those of humans.) Once the computer system had been installed, NODC's capability for service was immeasurably increased.

After they had familiarized themselves with the new acquisition, NODC personnel—particularly the programmers—promptly set about redesigning systems, adding new information, converting material from one form into others and, in general, spurring their obedient mechanical servant to greater and more complex efforts. The aforementioned computer-graphics work was one of the results.

A programmer's job is to define by written outline the basic operation to be performed, reduce a mass of data on a particular subject to a logical arrangement, then spell out each step and movement to be followed, and in what form. The next step is to record the data on coded cards in the language the computer understands, and then take whatever additional steps are necessary to ensure that the program is accurate and the data are in readily accessible forms. The full burden of logic and program organization is placed directly on the programmer. He must understand the capability of the computer in detail, know the use of each component of the system, and program their functions entirely. Imagination and perseverance are prerequisites of the job.

The programmers at NODC tend to be youthful, as befits the subjects under study. The pre-eminence of the computer as a working tool of science and technology was not, after all, achieved until the early sixties, when the second generation systems came into being. Roughly 20 years ago, there was only a handful of computer programmers in the country; now there are 300,000.

Most of the center's programmers are in their early or mid-twenties, and they are plainly members of the "now" generation in both appearance and attitude. Even their office decor reflects their dynamic spirit—more often than not the walls are covered with pop art (much of it computer graphics) or contemporary posters.

The programmers' work habits are not ordinary either. It is not unusual for some of them to become so engrossed in an experiment that they arrive in the middle of a weekend night and continue through the next day. At times, the average work day of some of the programmers has been calculated to be as much as 16 hours. When asked about the unusual schedules, an NODC official said:

"We tend to let them go at their own pace. By and large, their energy, enthusiasm, and creativity are prodigious and, on their own time, they often come up with interesting and valuable innovations. The best programmers seem to have a common attribute, which is that they cannot let a problem go unsolved—what might be described as a chessplayer's psychology."

NODC prefers, but does not insist, that its programmers have academic degrees in any one of several disciplines—mathematics majors work out well, but some successful programmers have held degrees in such fields as history or languages. Experience in programming is not a necessity for NODC programmers—whatever his background, an individual must spend a considerable period learning the NODC computer and systems. He must also attend courses in oceanographic data gathering in the field, covering such subjects as the function of water-sampling bottles, depth and temperature recorders, plankton sampling, hydrographic and oceanographic surveys, and how the data are distributed after they are gathered.

Computer programmer John Ward, who pursues the creative approach to computer graphics, developed and programmed a set of mapping routines so that data users might have at their disposal a considerable variety of computerized map projects and grids on which they could display their data. He began with a digitized file of a world map measuring 9 x 12 feet, made the mapping function into a computer program, then added scores of options to the whole. A wide selection of map projections is important to users because each one has a specific use in the representation of different kinds of oceanographic conditions or statistical data. For instance, the relation of winds and currents to one another or to the field of pressure is best shown against a conformal map; oceanic populations, rainfall, and evaporation, or other such areal quantities are usually best displayed on a map with equal-area properties; data that require correct distance need an equidistant map. Fifteen varying map projections are now available at NODC. Ward is presently working on a three-dimensional map of the Mariannas Trench, one of the most interesting features of the world ocean.

The physical operation of the computer graphics system seems almost like legerdemain. An operator sits at the keyboard of an instrument called the CRT (cathode ray tube) display unit; above the keyboard is a 29-inch (diagonal measure) screen similar to that of a television set. The operator proceeds to type in a statement ("CALL MAP"), which means that he wants the computer to project a world map. Instantly the map, divided by quadrants, is flashed onto the screen. The operator picks up a pen-sized flashlight (called a "lightpen") attached to the device and beams it at the northwest quadrant. A larger scale map which includes the United States is immediately substituted for the world map. Now a kind of rapid-fire "conversation" begins between the computer and the operator, conducted by the flashing light, the keyboard, and the screen image:

Q. "What format?" (Choices are listed.)
A. "Graphic."
Q. "What Marsden square?" (Image is divided into numbered Marsden squares.)
A. "Square 81." (Florida and the eastern Gulf of Mexico.)
Q. "Oceanographic station, or bathythermograph data?"
A. "Bathythermograph."
Q. "What months?" (Lists them by digits 1 to 12.)
A. "All months."
Q. "What years?" (Lists years.)
A. "1965 to 1970."
Q. "What depths?" (Lists available depths.)
A. "50 to 250 meters."
Q. "Averaged or at separate depths?"
A. "Both."

Many other questions might be asked, in addition to these samples. As the different maps and statistics are projected, photographs are made of the results, for more leisurely study. The end result of the procedure, which may take three to ten minutes, is a series of data summaries and maps that would take a minimum of seven to ten hours if drawn by a professional mapmaker. The same information can be converted to tape and computer-drawn copies soon after it is viewed on the display unit.

The much larger and more elaborate live-atlas computer-graphics program being developed at NODC is regarded as potentially one of the most important aids to oceanographic research ever developed. The idea was first introduced to NODC in 1965 by Dr. Henry Stommel and Edward Fredkin (both now at M.I.T.). Interest and enthusiasm ran high when their concept was presented, but the large-capability computer required was too complex and far too expensive for an organization with a limited budget. From the introduction of the theory to the present, experimentation and development of a live-atlas capability at NODC have centered on either adapting the concept to the computer equipment available at the center, or arriving at an arrangement whereby NODC-

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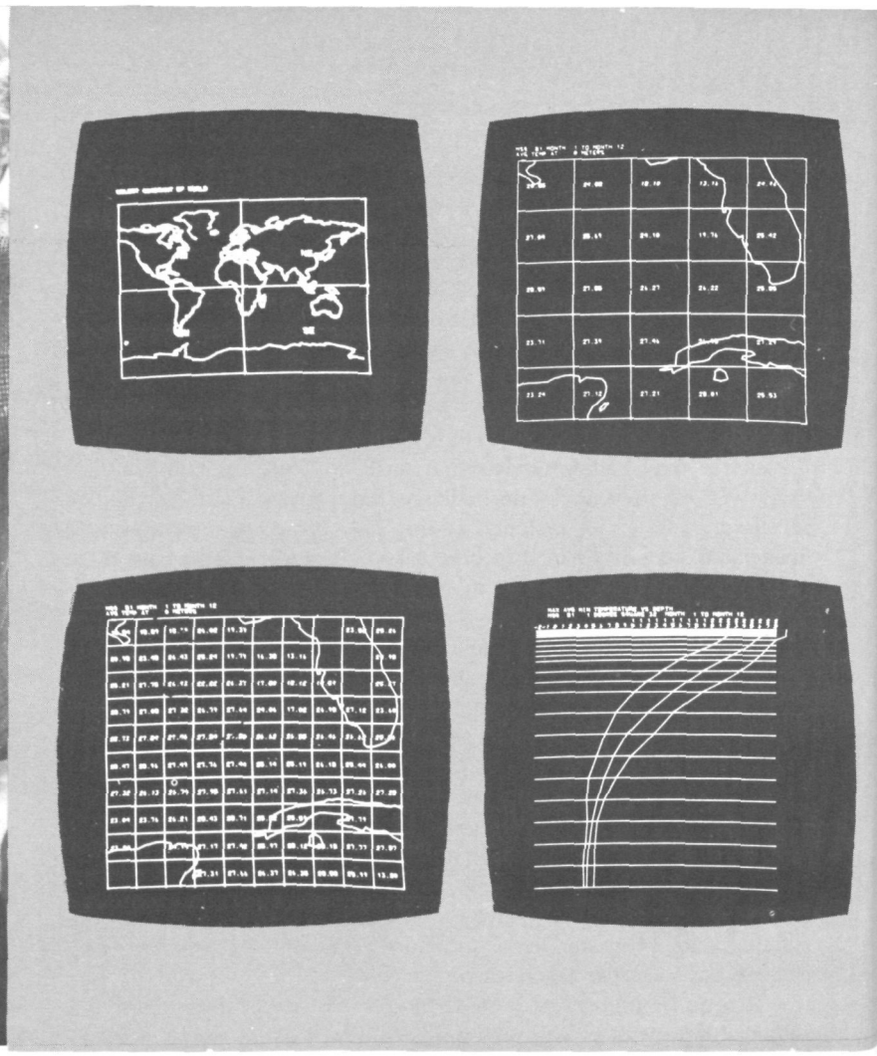


(Left) The "Live Atlas" displays water temperature contours for Walter F. Yergen. In the Center's computer-graphics program the first image shown (top left) is a map of the world. Making a series of choices, the operator obtains (top right) Marsden square 81 (Florida, eastern Gulf of Mexico, and part of Cuba) with 25 two-degree squares and temperatures at zero meters for all months; (lower left) average surface temperatures for 100 smaller squares; (lower right) vertical profile of maximum, average, and minimum temperature in a one-degree square.

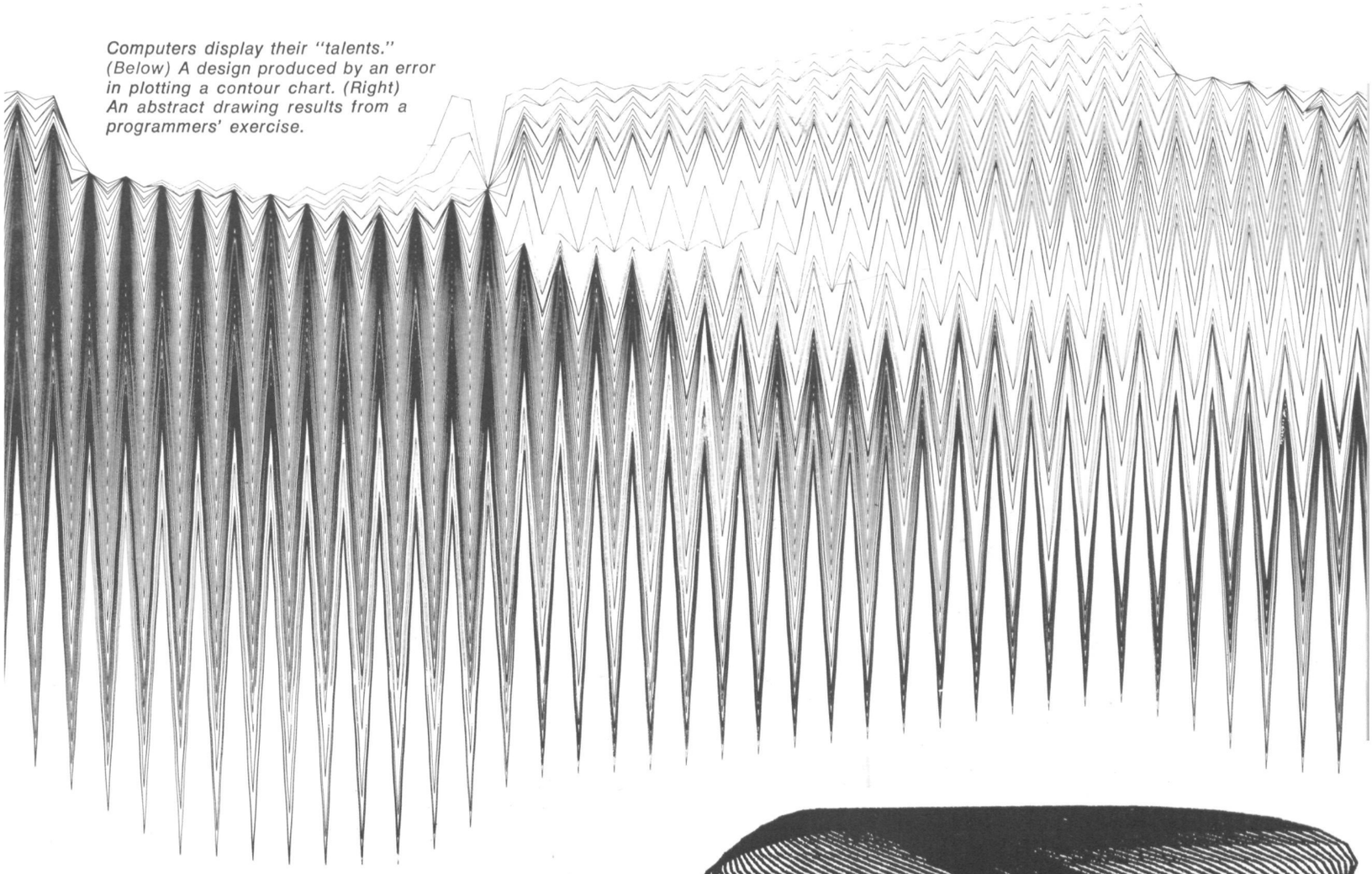
produced data might be processed on a more powerful computer at some allied institution, on a cooperative basis.

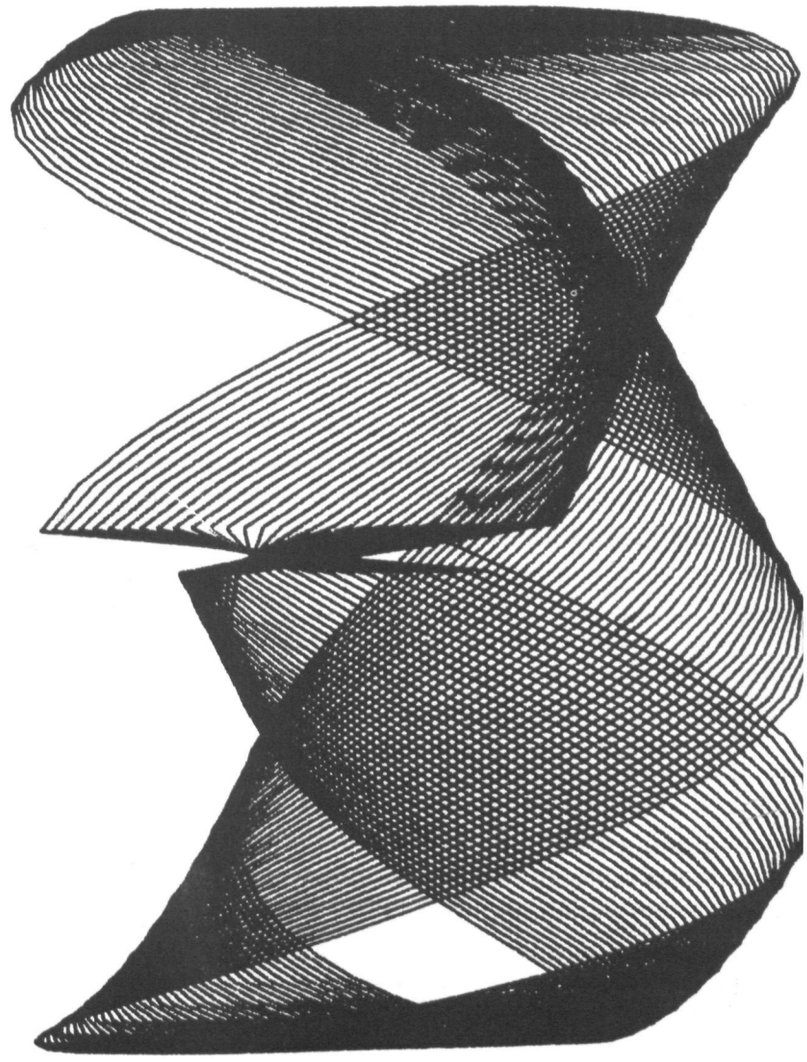
Essentially, the live atlas will be a memory bank containing enormous quantities of information on all aspects of marine investigation. All the data in the system will be stored in such a way that any part of it can be quickly projected on the screen of a display unit. But what makes the live-atlas concept different from others is that the data can be manipulated in dozens of different ways, to prove or disprove hypotheses, give forth missing factors based on known factors, test opinions, examine correlations, and allow a researcher to subject his data to alternative patterns or approaches. The user, in effect, interacts with the computer. If, for instance, an experienced oceanographer who has spent years studying a particular feature of the marine environment asks the computer about a certain point of information, and the answer requires modification, subjective opinion is brought into play. The oceanographer may, then and there, enter a modification by use of the lightpen or keyboard; the modification will be duly noted by the computer and added to the stored data. At some later date, after any such modifications have been reviewed and judged valid, the original data records can be revised to remove erroneous entries.

The value of the live-atlas approach can perhaps best be illustrated by describing two projects which could make use of the system. The first, now underway in the Coast Guard, seeks to determine patterns of drift followed by objects in large bodies of water, primarily so air-sea rescues can be performed faster and more efficiently. Such an investigation obviously requires a tremendous outlay of time, talent, and money to first collect the array of data on which conclusions can be based, then evaluate those conclusions, and then apply the findings to subsequent sea disasters. A live atlas could pinpoint in mere minutes, for instance, the location of a downed aircraft if the data bank contained previously stored and programmed back-up data on drift patterns, combined with general information about the site of the accident. Concrete results could be the saving of lives and less costly search operations.

The second example of a potential user of the live atlas might be a scientist interested in surveying marine waters to locate the correct environment for an aquaculture experiment. Perhaps the species under consideration for rearing is the pompano. The scientist would know, before he approached the computer-graphics system, many of the conditions to be met—the type of bottom conditions "preferred" by pompano, the most suitable range of temperature, the type and quantity of nutrition required for survival, and certain of the chemical aspects of the pompano's habitat. The information in hand may have been gathered in a relatively small region, however, and the scientist may want to know about findings in quite different locations; or he may wish to learn about studies

Computers display their "talents." (Below) A design produced by an error in plotting a contour chart. (Right) An abstract drawing results from a programmers' exercise.





done in the past that relate to the subject. It might be important for him to discover what might happen to the fish if the water temperature unaccountably dropped or rose, if the composition of the food chain were altered perhaps because of a sudden bloom of phytoplankton, if the oxygen and salinity content of the water changed, or what combination of nitrates and phosphates was most desirable. By rearranging his data and asking the computer to consider various sets of alternative effects, the scientist could presumably receive answers to all these questions and a whole host of others. Information obtained through the live atlas—in effect, a blueprint of the proper ambience for rearing pompano—might very well mean the difference between the success or failure of the project under consideration.

One oceanographer involved in the development of the live atlas waxed eloquent and imaginative in describing its world-of-the-future possibilities: "If I had the necessary data programmed into the computer, I might ask it to show me a model of the Gulf Stream," he said. "Then, by lightpen, I could wipe out the Stream entirely and, by asking the right questions, I could find out what the world would be like without a Gulf Stream!"

Plainly, the evolution of computer systems for scientific use has come a long way in a short time, and the end is by no means in sight. Ultimately, computer scientists hope to perfect machines that can read ordinary printed matter and respond to spoken words. Improvements and adaptations seem almost self-generating, and as human needs for information increase and become more complex, no doubt the systems that seem like miracles of efficiency today will become tomorrow's Model-T's. □

The National Oceanographic Data Center

Data disseminated by NODC takes many forms, from the printed word, including charts and atlases, to magnetic tapes and maps. Requests handled range from questions about a small patch of saltwater in some isolated estuary, to detailed resumes of everything known, oceanographically speaking, about an area as large as the Caribbean Sea. Not long ago, for instance, the data center was able to advise a man who was concerned about the likelihood of a confrontation with jellyfish during his seashore vacation. At the same time, NODC, along with the American Meteorological Society, Gulf University Research Corporation, and Texas A and M University, were working on the production of three volumes (several thousand references each), as well as microfilmed records, of known information on physical/chemical oceanography, meteorology, climatology, marine geology, geophysics, and marine biology for a major international research program involving 15 countries, called the Cooperative Investigation of the Caribbean and Adjacent Regions (CICAR).

Quite simply, NODC came into being because a genuine need existed for such an organization. Technological advances made from the late forties through the fifties, plus an accompanying acceleration in the gathering of oceanic data, had combined to produce—by the mid-fifties—mountains of invaluable data, scattered throughout the world. Earlier methods of converting such material into useable forms could only be described as primitive. Many of the data gathered at sea were transcribed by hand aboard vessels which might not return to home base for months; even after data were delivered to a processing center, conversion into understandable forms took months, even years; and many laboratories and research institutions had an extremely narrow range of dissemination. One oceanographic investigator might spend months in merely searching out sources of needed information, then additional months in obtaining the required data, and still more time preparing his findings for publication.

With the advent of diversified types of computerized systems able to process all kinds of information quickly and accurately, and produce well organized compilations, a whole new age dawned for those in need of marine-related data. Once the NODC was established, it became a focal point for national and international oceanographic interests.

Who are some of the clients served by NODC? Almost everybody it would seem, with an interest in questions about the oceans: the White House; Members of Congress; most of the Departments of the U.S. Government and many of their subagencies; state governments; foreign governments; universities, technological and research institutions, and industrial firms in this country and abroad; international agencies, such as the Food and Agricultural Organization of the United Nations; and fishermen, miners, oilmen, drug manufacturers, inventors, and students of all ages.

Information available from NODC is equally varied. Subjects covered range over the whole spectrum of the marine environment; life, minerals, and chemicals in the sea; physical characteristics of the water at the surface, at various depths, on the bottom, and at coastlines. Poseidon himself would have coveted the storehouse of oceanic information available at the center.

What data are available?

Mechanical and expendable bathythermograph (BT) data in analog and digitized form.

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

Salinity-temperature-depth (STD) data in digital form.

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

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

Geological sampling inventory (primarily for the New England Continental Shelf).

Bottom sample descriptions.

What services are provided?

Data processing.

Data reproduction as required (printed listings, punched cards, magnetic tapes, etc.).

Analysis and preparation of statistical summaries based on archive holdings.

Evaluation of suitability or limitations of various data records for specific analytical requirements.

Library search for bibliographic references, abstracts, and documents.

Referral of requesters to organizations holding information desired.

Provision of general information concerning the marine sciences.

Supply of publications, including data processing manuals, catalogs of holdings, data reports, and atlases.

What should requests for services contain?

Definition of data desired.

Limits of geographic area.

Any other information pertinent to assist in filling a request—for example, information on the research or operational problem for which the data are required.

Formats obtainable are:

- Magnetic tape
- Punched cards
- Microfilm
- Hard copy (machine listings, publications, analog charts).

Cost depends upon the number of observations involved, special analysis required, computer time used, material needed, etc. Requests for small amounts of information are completed free of charge; otherwise, a cost estimate is presented to the requester and work begun on receipt of funds.

The User's Guide for NODC's Data Processing Systems, available upon request, provides detailed information concerning data holdings.

About 2500 reels of magnetic tapes are stored at NODC.

NOAA Profile

What's in a name? When it come to places, ask Joseph Wraight.

PUTTING A NAME TO IT

Few parents will forget the anguish they went through in deciding what to name their children (and some children will never forgive them for the outlandish names they chose).

Unlike parents, Dr. A. Joseph Wraight wrestles with the problem all the time, but in a slightly different form. He must help decide the name for geographic locations in the United States—lakes, rivers, islands, peninsulas, promontories, bays, sounds, harbors, tributaries, communities, mountains, hills, valleys, shoals, channels, and beaches, to name just a few.

For Wraight, a geographer and historian, represents the Department of Commerce on the interagency U.S. Board on Geographic Names, of which he is Acting Chairman, and its Domestic Names Committee. The board decides what names shall appear on U.S. government maps and charts and other publications. Its decisions are usually followed by other political entities, such as states and counties.

Wraight is the Chief Geographer of NOAA's National Ocean Survey. His work on the Domestic Names Committee can, as he put it, "get quite sticky at times." Many people have strong feelings about geographic names, especially those applied to local features in which they are interested.

The Committee's task is sometimes complicated by the fact that its concern with grammar must be tempered by certain practical considerations. It has a policy to avoid the use of diacritical marks, such as apostrophes, hyphens, and accent marks. Periods are often left out also.

There, for example, is a Lockwoods Folly near Southport, North Carolina. "It seems," said Wraight, "that many years ago the owner of some land at the head of an inlet built a boat. But when he came to sail it out, it was too big to get through the narrow end of the inlet and it just sat there and rotted. So people called the inlet Lockwoods Folly and that's the way it appears on our charts."

"I guess," added Wraight, "Lockwood never heard of the story of the man who built a boat in his basement."

Everyone knows it should be Lockwood's Folly, with an apostrophe. But it's not, because diacritical marks are avoided. Wraight explained why.

"The board's policy is not to use diacritical marks, especially on nautical charts, because they could be misconstrued. Charts are covered with all kinds of marks, many of them designating navigational aids which tell a mariner what he can expect to find in the water he navigates. If someone confused a period on his chart with a navigational aid, he could be in trouble."

In rare cases, bad grammar seems to be inescapable, Wraight said.

"Consider the case where sex reared its ugly head. Masculine and feminine nouns got mixed.

"There's an island near Ft. Myers, Fla., which was known at one time or another as Cayo Costa, Cayo Costa Island and La Costa Island. The Spanish name originally was Cayo de la Costa, meaning 'Island of the Coast.' Eventually the name was shortened so that it was generally known locally as Cayo Costa.

"Years ago it didn't make much difference, but as the place began to build up, it became necessary to place it on a nautical chart and the board was faced with making a decision on what to call it. This was some years ago, and the board decided that Cayo Costa was bad Spanish because both words should agree in gender and Cayo was masculine while Costa was feminine. So they decided upon Lacoasta Island.

"That stood the test of time for about

continued

CABO FRIO

30 years, until a Power Squadron group picked the island to hold their meetings. It then developed that although the board had changed the name, the state and locality had not and some of the 100 Power Squadron members had difficulty finding Cayo Costa on their charts because it wasn't there under that name."

Consequently, concluded Wraight, the board decided even though the grammar was bad and the sexes were mixed, to return to local usage and rename the island Cayo Costa.

Some names just disappear from government maps and charts, said Wraight, although they may continue to be used locally. One example of this is Nansemond River, near the Norfolk-Newport News-Hampton Roads area in Virginia. On the other hand, some names which have disappeared from maps and charts are later restored to life, like Lazarus rising from the dead, and officially recognized once again by the federal government.

"There are many places, such as high bluffs bordering deep water, where no one has lived for years, from which the names have been dropped, although they were continued locally," explained Wraight. "In colonial days, they were often important. Deep sea sailing vessels would land supplies there. This practice continued until the Civil War. Then, with the increase in the size of oceangoing vessels too large to sail where earlier vessels had gone, and the coming of the railroads, these landings fell into disuse, although the names persisted locally.

"But now, with the rapid increase in the use of small recreational craft, many boaters are again using these landings and need a name on their charts to go by. Furthermore, the Coast Guard finds them useful in directing rescue operations. So the names are being resurrected and are reappearing on nautical charts."

Sometimes nature eliminates names. During the devastating east coast storm in 1962, inlets and islands disappeared and their names had to be removed from maps and charts. Hurricane Camille also caused some islands to vanish. Sometimes a storm or the natural effect of wind and waves will cause new channels to form and then new names appear on maps and charts.

When the board changes a name, it has far reaching consequences. All federal agencies must follow suit and many states, counties, and localities do the same to avoid confusion. The National Ocean Survey must fit the new name, or eliminate a name, from its charts. All new charts and revised charts are checked with Wraight before they are printed to assure accuracy.

The Interior Department's Geological Survey, which provides staff support for the board's domestic names functions, prints the board's decisions and distributes them widely to government agencies concerned with the production of maps, and to other public and private organizations having an interest in geographic names.

Sometimes a storm or the natural effect of wind and waves will cause new channels to form and then the Board on Geographic Names must select new names to appear on maps and charts. (Left) Aerial views of Assateague Island off the Maryland shore before (above) and after (below) the March storm of 1962.

The Board on Geographic Names is composed of representatives of 12 government agencies. It functions as a full board on policy matters, but within the policy framework, work on domestic and foreign names is conducted mainly by two committees. The work on domestic geographic names is handled by the Domestic Names Committee on which are representatives of the Departments of Commerce, Agriculture, Interior, Postal Service, and Government Printing Office. The Foreign Names Committee includes representatives of the State and Defense Departments, Navy, Air Force, Central Intelligence Agency, and the Library of Congress. Name decisions are subject to review and approval by the Secretary of the Interior.

Investigations are conducted to determine names used in local areas, as local usage is generally a paramount consideration when name change proposals are reviewed. Investigators talk to residents, especially longtime inhabitants and local government officials, and search court records. NOAA ships have standing orders when they visit sparsely settled areas to determine names used there for geographic sites. Names will be required as charts are published of the areas.

The board's policy is to endorse, whenever possible, the local usage of names. Thus, should people in a certain locality call a spit of land the "Cat's Meow" for as long as anyone can remember—especially if there were facts to justify it—then the board likely as not would go along with local usage.

But dependence on local usage can lead to embarrassing situations, because in some instances geographic names have an obscene connotation and the geographic features are unashamedly referred to by local residents in such manner. Some of these place names have stood the test of time, some going back centuries.

But, as Wraight pointed out, "obviously we cannot endorse the placing of obscenities upon official documents of the United States Government."

What to do and still not ride roughshod over local custom? To this date, said Wraight, with pride, the board has been able to reach a suitable compromise in nearly all cases.

Wraight has been interested in geography as long as he can remember. He is the author of various books on the subject, including *Our Dynamic World; A Survey in Modern Geography* and *The Field Study of Places*. A native of St. Louis, Mo., he majored in geology and geography at Washington University, taught at the university and obtained his master's degree there in geology and geography. He received his Ph.D. in geography from Clark University, Worcester, Mass.

Wraight has been with the National Ocean Survey and its predecessor Coast and Geodetic Survey since 1940, except for a wartime stint with the Interior Department when he was engaged principally in military intelligence with the Board on Geographic Names' predecessor.

After seven years of field work with the Coast and Geodetic Survey, he was assigned to the agency's Geographic Names Section. It was then, for the first time, that he was classified as a geographer. Before that he was known as a cartographer or cartographic engineer.

In 1960, he was named chief of the Geographic Branch, which included several units in addition to the Geographic Names Section. That's when he got the title of Chief Geographer.

The way Wraight explains it, there are a number of geographers in the agency, but they are employed as cartographers or cartographic aids. Rear Adm. James C. Tison, Jr., told Wraight: "You're the only person classified as geographer, so that makes you the chief geographer."

Some years earlier, in a similarly informal manner, another director, Rear Adm. H. Arnold Karo, had made him the unofficial historian of the agency. The Coast and Geodetic Survey was preparing to observe its 150th anniversary in 1957 when the agency suddenly discovered it had no official history. Wraight got the chore and the result was *The Coast and Geodetic Survey, 1807-1957*, which he coauthored with Captain Elliott B. Roberts, chief of the sesquicentennial's steering committee. Publication of the brochure ended the chore, and that's why the agency is without an official history for the years 1958 and on.

Wraight has had many interesting assignments while Chief Geographer, but the one of which he is perhaps proudest concerns the research he did in 1952-53 in the tidelands oil case when the U.S. Supreme Court was deciding the ownership of the oil-rich tidal waters as between the states and the federal government.

His participation culminated in his appearance as a government witness before a special master of the Supreme Court. Some of the most trenchant cross-examination of witnesses, especially those whose testimony favored the federal government's case, came from the Attorney General of California, one of the states off whose shores oil had been discovered.

When Wraight completed his testimony, the Attorney General waived his cross examination.

Wraight has been a full member of the Board on Geographic Names since 1964, serving prior to that as an alternate. He is the chief authority in the nation on the history and nomenclature of geographical features along the coasts of the United States because the National Ocean Survey is the federal agency which must apply names of coastal features on the nautical charts and other marine publications it prepares and publishes for the government. □

1971 forecasts will be based on a systematic ladder of choices.

HURRICANE YES OR NO

Hurricane forecasting is a double-edged sword, says Dr. Robert H. Simpson, Director of the Weather Service's National Hurricane Center, in an interview for NOAA Magazine. Warnings must be issued where a positive threat exists, but false alarms can destroy public confidence in the warning service.

Q. Dr. Simpson, what new tools or methods are you employing this year in hurricane forecasting?

A. We have essentially the same tools and sources of data as before, but we have a new decision-making process.

Q. How is it different?

A. This year we have organized what the forecaster will do into formal, step-by-step procedures in which the forecaster moves methodically from one yes-no decision to the next to decide just where a storm is going and how strong it will be when it arrives.

Q. How do you expect this will improve forecasts?

A. Mainly by assuring that each forecaster answers the same questions in reaching a decision This will provide homogeneity from one forecast shift to the next. Then, when the season is over, we can review our successes and failures and see just where we went wrong, because we will know in each instance just what the forecaster asked himself and how he answered.

Q. Are you confident that this will upgrade hurricane forecasting all across the board?

A. Yes indeed—in predictions of strength, speed, and direction of the storm. It won't cut over-all errors in half or improve our understanding of storm dynamics a great deal, but it will help us sort out the best forecasting techniques, the best concepts. I expect some we now rely upon heavily will be found wanting, while others will be elevated in status. Most importantly, it will help us limit the potential for a bad bust—that is, a completely missed forecast.

Q. Could you explain that a bit?

A. I think the science of hurricane forecasting has reached a plateau. So the way to paydirt, as I see it, is to make sure we do the best we can with what we have. Systematized "decision ladders" should provide the uniformity to do this, once we have determined the best forecasting techniques.

Q. How important now are satellites in hurricane forecasting?

A. The National Hurricane Center is relying on them more and more. Satellites are a central part of our operation—particularly the ATS-3 satellite over the Atlantic and the ATS-1 over the Pacific. These are the so-called synchronous or geostationary satellites—they seem to hang motionless 22,300 miles up, because their orbits have been timed to coincide with the rotating earth.

Q. What makes them so valuable to you?

A. They provide us with pictures of a tremendous area—half the earth, almost—from the same place in the sky every 26 minutes during daylight hours. The detail in these pictures will show anything two miles or more across. So hurricanes and individual clouds within them show up clearly.

A most exciting development here is the movie loop, which gives us a time-lapse motion picture of a hurricane. By piecing together the 17 pictures from ATS-3 taken during a single day, we can produce a closed loop of movie film which can then be run through a projector so that we can watch, over and over again, what is happening to the cloud systems in that hurricane.

Q. What can you learn from these?

A. First, whether the storm is growing in size and intensity. Second, the direction and speed with which the center is moving.

Another interesting use of ATS-3 pictures is to measure wind speed in a storm by measuring movement of individual clouds. On enlarged photographs, with grids superimposed on the pictures we can actually measure how far a cloud travels over the earth in the interval between pictures. And this gives us a pretty good idea of the wind that is transporting that cloud.

Q. Are these as good as wind measurements you get by tracking an instrumented balloon—that is, by rawinsonde?

A. No. They are not as accurate. Their chief values lies in the abundance of the observations you can make—one per cloud, almost.

Q. What makes them less accurate?

A. One problem is that the wind does not always carry the clouds at the speed of the wind. The wind blows through the clouds at times. Also, some types of clouds evaporate on one side and build on the other, which distorts their measurable motion. Our operators are learning to recognize these peculiar types and avoid using them.

Q. Are these studies providing you with new information on cloud dynamics?

A. No, not really. We've known about these effects before. But they certainly are gloriously displayed by satellite.

The main contributions of the satellite are that it detects storms early and gives us the big picture of what a hurricane or storm is doing, including the surrounding environment which will determine whether the storm will grow or shrink, or whether it will remain a benign seedling.

We have about 110 hurricane seedlings which parade across the scene each year. Only 10 or 11 of these actually grow to named tropical storms or hurricanes. The satellite tells us a lot about which ones will grow, providing information over an area much too large for aircraft to scout.

Q. What makes a fertile environment for a hurricane? What do you look for?

A. First, the winds at all levels except the very highest must tend to blow in the same direction and at about the same speed, with no strong shear forces tending to disrupt the accumulation of heat in a central core. This warm core is the engine of the hurricane.

Second, there has to be an outflow, an exhaust system for the hurricane, very high up at the jet-stream level. If the forecaster spots a high-level wind which will conduct heat rapidly away from the top of the hurricane chimney, he looks for explosive strengthening of the storm, such as we had in Hurricane Celia last August.

The effect here is similar to what happens on a cold, windy day to a fireplace chimney. The strong breeze conducting heat away from the top of the chimney strengthens the updraft and makes the fire really roar.

Third, there has to be a circulation at low levels favoring transport of air into the storm. Otherwise, the storm will be starved for mass to sustain itself and will weaken.

Q. Now that you have satellites, do you really need reconnaissance aircraft and radar to locate and track hurricanes?

A. Most decidedly. The three observing instruments complement each other. We need them all.

The airplane is indispensable because it is the only way we

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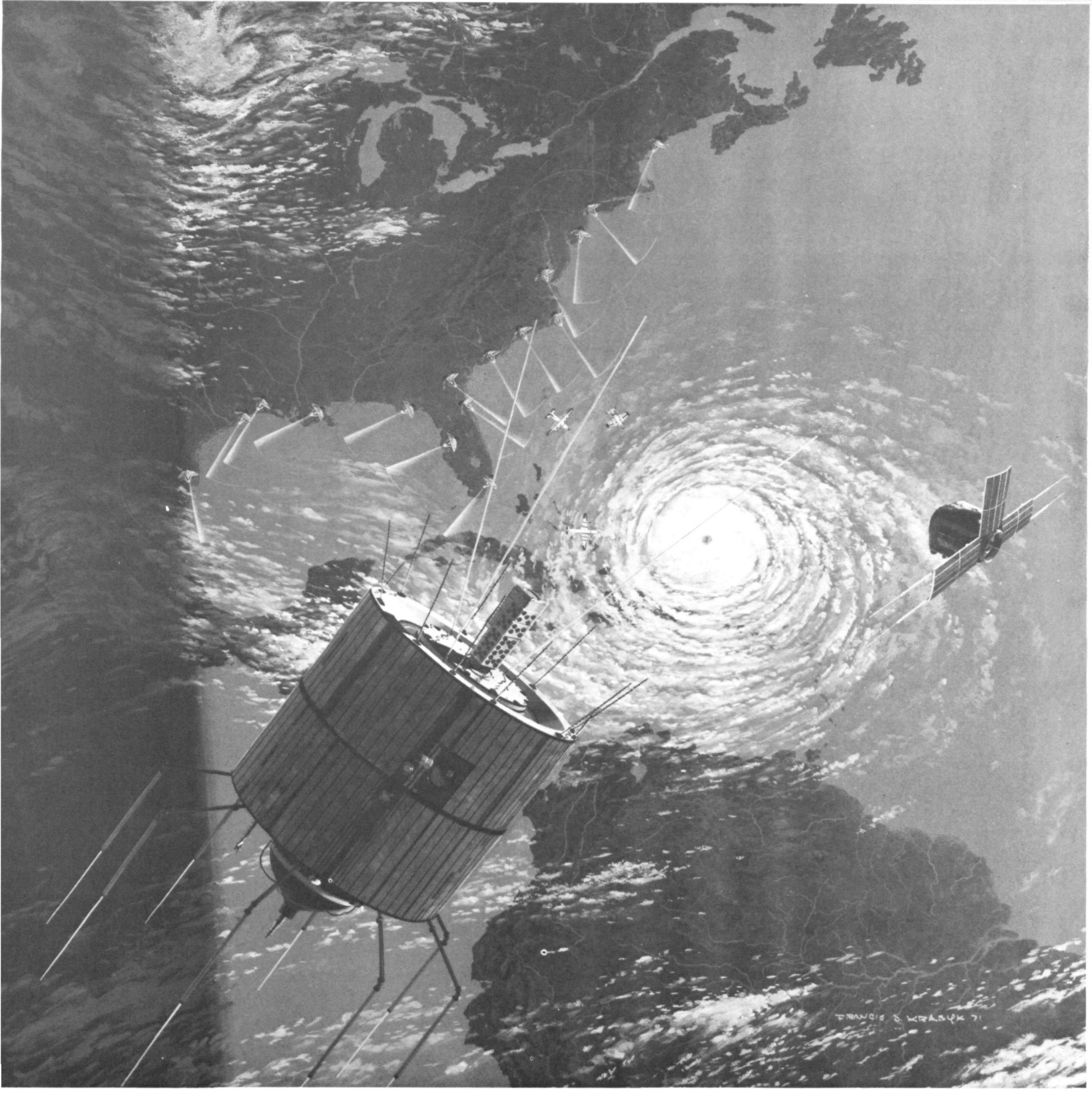

Eyes on the hurricane include satellites, reconnaissance aircraft, and radar. NASA's Applications Technology Satellite (ATS-3) keeps continuous watch from its post 22,300 miles above the Equator, while the NOAA-1 spacecraft photographs the hurricane from a much lower polar orbit. Air Force, Navy, and NOAA aircraft prepare to fly inside the storm, where they will measure the forces that drive it. Along the coast, weather surveillance radars form a picket line of defense, waiting for the hurricane to move within their 250-mile range.

can get inside a hurricane and actually measure the forces that drive it—pressure gradients, wind gradients, and temperature gradients—giving the forecaster numbers to base his forecast on. It is our only dependable means of telling whether we're dealing with a superstorm or just a moderate one.

Take Hurricane Camille, our greatest storm, which devastated the gulf coast of Mississippi in 1969. We didn't know for a while whether it was growing into a superstorm or diminishing. Satellite pictures showed Camille had shrunk in diameter. Some said it must be weakening; others said the opposite. As a matter of fact, it was winding up, intensifying into one of the most devastating storms ever to strike the U.S. coastline. We found this out by getting an airplane in there just in time to learn how strong the storm was and issue appropriate warnings.

Camille's strength surprised everyone. Minimum pressure was 905 millibars, lowest ever measured by aircraft and second lowest on record for an Atlantic storm, second only to the Florida Keys storm of 1935, which had a minimum pressure of 26.35 inches (892 millibars).

Because of what was learned by reconnaissance aircraft, we were able to put an exclamation point after our warnings, and say: "This is a greater storm than Hurricane Betsy, which you experienced here in 1965! This is a whopper of a hurricane—run for your lives!"

And people did run for their lives—75,000 of them.

Q. How strong were the winds in Camille?

A. The aircraft estimated winds of 175 knots (201 miles an hour), looking down at the surface condition. But, in my opinion, the maximum measured speed bore no relationship to the true speed. I think we'll never know what the winds were in Camille. From the pressure gradients we measured—nearly 4 millibars per mile—I suspect nearly 200 knot winds (230 miles per hour). I think that's probably a good figure to use.

Q. How about radar? What does it give the hurricane forecaster?

A. Coastal radars provide a picket line of defense. Radar gives the forecaster a precise track of the hurricane as it approaches the coast and gives him an aiming point for landfall. It tells him during the critical last hours whether the storm is intensifying or diminishing, expanding or contracting. It may not provide actual numbers for its strength, but he can infer a lot from the character of the rain bands.

Q. How far can the radar see?

A. That's one of its limitations. The nominal range of our radar is 250 miles. But it will pick up a hurricane at that distance only if the eyewall reaches up 35,000 to 40,000 feet, because of the curvature of the earth. Radar sees in a straight line, like the human eye. At 250 miles, the main body of the hurricane will be down below the antenna's line of sight.

Even if the radar does provide enough of a picture at that distance—from isolated cloud cells reaching up—to provide a fix, that gives only about 17 hours to track the storm as it approaches, assuming a forward speed of 15 miles per hour.

Another problem with radar is that it may give an inexperienced viewer a false notion of where the eye is. Frequently in the radarscope the eye will change shape—from circular, to a horseshoe shape, to an elongated, pulsating ellipse. Inexperienced observers, such as those viewing radar scopes displayed by some TV stations, can be fooled into thinking the eye is somewhere it isn't—a very dangerous thing, in my opinion. It could lead people who have been warned to evacuate to stay home. Today, with radars being placed on television from so many different sources, I think this could be a real problem.

Q. The message here?

A. Heed the official warnings from the National Weather Service.

Q. How did forecasters deal with hurricanes in the old days, before they had satellites, reconnaissance aircraft, radar, and radio?

A. Before radio, there wasn't much they could do. With the advent of the wireless telegraph, around the turn of the century, advance warnings became available from ship reports, together with reports from a few island stations, that large storms were moving westward across the ocean.

Q. Were warnings spread over much larger areas in those days?

A. Yes, and that has been the problem, historically.

The warning service has always been highly dedicated, with people working their hearts out trying to understand what's going on, trying not to overwarn, but at the same time spreading warnings wherever they thought necessary to be sure no one was caught unawares where a storm crossed a coastline.

This has led to gross overwarning, on occasions. Back in the early years of World War II, when a number of agencies were issuing hurricane forecasts, I can remember a case where there were storm or hurricane warnings flying simultaneously from Brownsville, Texas, to Cape Hatteras, North Carolina—the entire coastline around the Gulf of Mexico and along the south Atlantic states—all alerted by a single storm.

This type of uncertainty and overwarning led to our present system where the National Hurricane Center is recognized as the single agency responsible for preparing military as well as civilian forecasts for all North Atlantic hurricanes.

Q. What is the maximum coastal area that now would be alerted because of a single storm?

A. For a hurricane warning about 200 to 250 miles—and I think we can improve on that, with new systems now available and new tools of decision we're developing, to 100 to 150 miles or less within the next 10 years.

That's for a hurricane warning. Be sure to distinguish between the watch and the warning. The hurricane watch covers a larger area. We try to get that out about 30 hours in advance to alert people that they must be prepared to take fast action if a hurricane warning is issued for their area.

When we reach the next step, the hurricane warning, it means there is a high probability that a hurricane will strike your locality within 24 hours. This should give a minimum of 10 to 12 hours of daylight for people to get ready before the hurricane moves in, allowing leeway for a possible landfall at night, and for the fact that destructive winds and rising tides may precede the full fury of the hurricane by several hours.

Q. Why is it so important not to overwarn?

A. For economic reasons and to avoid losing public confidence in our competence.

Economically, it's very important not to issue a false warning for, say, the Gold Coast of Florida (Palm Beach southward through the Greater Miami area). A hurricane warning in this area calls for a programmed expenditure of about two million dollars by corporations and businesses which have determined exactly what they will do. These are expenditures that definitely will be made, whether it's a moderate or severe hurricane. And, of course, there are many more expenditures by individuals who board up their houses and so forth.

So if we paint our warnings with too broad a brush, this will

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cause great waste and unnecessary effort. Soon, people will be less prone to heed our warnings.

Q. If you get your warning sectors narrowed to 100 miles, this wouldn't leave much on either side, would it, with a big hurricane?

A. A large, mature hurricane may have hurricane-force winds (74 or more miles per hour) over a 75- to 100-mile stretch. Others may be much smaller. The Keys storm of 1935 had hurricane-force winds over only about 35 miles. Celia covered 60 miles; Camille, 75.

Q. What are your most pressing needs in hurricane forecasting?

A. They fall into two categories: research and operational. In research, we need to know just what it is that makes a hurricane move along a track. That may sound strange, but no one really has ever described the mechanism of atmospheric circulation that causes a hurricane to move from point A to point B. It's quite complicated, involving an interaction between the spiraling winds of the hurricane with the larger-scale winds of the surrounding environment.

Nearly all numerical-prediction (computerized) methods start, oddly enough, by taking the hurricane out of the picture. They simply predict where the environmental currents are, around the hurricane, and how their configurations will change.

Yet everyone who deals scientifically with hurricanes knows there is an interaction between these carrying currents and the hurricanes themselves. And it is these interactions that determine the critical, small movements that lead to a straight or curved track —between moving in over New Orleans or, say, Mobile.

At present, our average error in predicting where a hurricane will cross a coastline when still 24 hours offshore is about 100 nautical miles. That is because we cannot predict closer than about nine degrees the actual path of the hurricane.

This is the frailest part of our forecast. And, in the final analysis, it is the most important payoff to the public—the point of landfall.

Q. Any progress being made?

A. We have a plan this year we hope will place a handle on the problem. It involves a numerical-prediction model—a diagnostic model—by which we will try to determine where a hurricane will go if conditions around it are exactly observed. With our model, we will artificially change one element, then another and another in the environment—and through a cut-and-try process see if we can find out which changes cause our model hurricane to shift direction.

Q. What do you think some of these steering elements might be?

A. I could enumerate possibilities for 20 minutes. I suspect the fundamental thing is intrusion of different temperatures in the middle troposphere—the 500-millibar or 20,000-foot level— in advance of the hurricane. But that's just my educated guess.

Others on my staff would quickly say the most important thing is a change in speed and direction of the jet stream—at about 35,000 feet—ahead of the hurricane. I happen to feel that the jet stream is more important to the hurricane's strength than to its direction.

Q. How about your operational needs?

A. Here, our greatest need is for more systematic collection of information from aircraft. We need information collected in the same way each time, along tracks we have prescribed—data collected with instruments of uniform calibration and character, under completely standardized conditions.

And we need to have this information transmitted to us dependably and promptly—directly to the Hurricane Center—for processing.

Reconnaissance planes of the Department of Defense began last year to meet some of these needs, and will continue this year.

Q. What kind of information had you been getting before?

A. As in the past, the assigned task of hurricane-reconnaissance planes was simply to provide point information—that is, the geographic location of the eye of the hurricane, and the velocity of the strongest winds.

Now, useful as this is, it tells us nothing about the distribution of wind or pressures—what the meteorologist calls gradients—and it is these gradients that determine the forces in a hurricane and the changes that will occur. What we urgently need is a profile of gradients of pressure, temperature, and wind as one proceeds diametrically across a hurricane through each of its four quadrants.

And we need to be able to receive and process this greatly increased data quickly enough for a forecaster to interpret it and perhaps send back a query to the plane questioning what was sent or asking for an eyeball assessment of the clouds that were present where the changes were measured.

Q. Once you have these gradients, what, specifically, will they tell you?

A. They will help us avoid present ambiguities of determining just where the center of a storm actually is. Post mortems on hurricane forecasts have shown that even a plane going directly into a storm can't pinpoint the center. When we review data from all sources—aircraft, radar, satellites, ships, and rawinsonde stations on the ground—we find the average error in positioning storm centers has been 20 to 30 miles. Last year, it was 23 miles for all storms; the preceding year, 31.

Now this is a large percentage of the total error that we have in our forecasts.

Q. What causes these positioning errors?

A. Two things: imprecise navigational equipment and ambiguities about what constitutes the center of a hurricane.

The first has been flagged for correction. There are plans in the offing to replace present, obsolete navigational gear with more precise equipment such as Omega and Loran-C.

The other source of error—doubts about what constitutes the center—stem from focusing on the eye of the hurricane as the center. If you say the center is the geometric center of the circle outlined by the eyewall, you're frequently in trouble because the eyewall may not be circular but an arc or an ellipse. And even a perfectly round eye may not give you the exact center of the storm mass. The eye is the consequence of, not the cause of, the battle going on around it. It is not something in itself that clearly identifies the center of the massive body of circulation.

Q. How do you determine the hurricane center, then?

A. I think by determining the ring of maximum wind—the highest kinetic energy within the storm. It changes less from hour to hour than other frequently used indices of a storm center, such as points of minimum wind and pressure and maximum temperature.

These latter three, incidentally, are almost invariably three different points.

Q. But how do you get simultaneous measurements of points in this ring of maximum wind?

A. You don't. You can't have four aircraft at once flying across the ring. What you do is send a single aircraft, first, from left rear to right front, across the ring, which gives two points. Then have it go around to the left front quadrant and return across the eye to the right rear. Now you have four different points at four different times.

The hurricane warning means there is a high probability that a hurricane will strike your locality within 24 hours. This should give a minimum of 10 to 12 hours of daylight to get ready before the hurricane moves in. Mobile homes are especially vulnerable to hurricanes and residents should be evacuated when a hurricane threatens.

With a computer, you can take this information and determine exactly where the center of this moving ring of maximum wind was at a given time. And this gives you a position accurate to within about one mile of the center of the hurricane.

Moreover, the glue that holds this storm together is portrayed to the forecaster in terms of profiles of pressure and temperature and wind across the inner vortex, where the energy is concentrated.

Q. What would you need to transmit and process this information?

A. We couldn't do it with equipment now in use. In order to transmit millions of digital bits of information in a logical, coherent form which can be processed by computer and used in real time by the forecaster, we probably need a satellite to act as a relay between the plane and the Hurricane Center. It's well within the state of the art.

Q. How many and what kinds of planes are involved in hurricane reconnaissance?

A. It varies somewhat from year to year. Nominally, there have been five or six C-130 Hercules available through the Air Weather Service out of Ramey Air Force Base in Puerto Rico; and the Navy has had an equal number of C-121 Constellations, some out of Jacksonville, Fla., and some out of Roosevelt Roads, Puerto Rico. This year, the Navy also will be flying a later-model plane, the P-3 Orion.

Q. You have expressed concern about growing densities of population in low-lying coastal areas where hurricanes are a threat. Would you care to comment here?

A. Yes, I'm glad to, because that has been a keynote in our hurricane-preparedness meetings this year.

I think the Hurricane Center and NOAA have a responsibility to call attention to this problem. The United States is building toward a disaster from hurricanes along its coastlines, in some areas.

With more and more people building more and more homes closer and closer to shore, population density is about to outrun the forecaster's ability to give adequate warnings, particularly in coastal areas where there are limited escape routes.

My concern is based on the fact that we cannot appreciably increase the amount of warning time beyond what we can give people now—which we try to maintain at a minimum of 10 to 12 daylight hours.

There are many areas where evacuation routes are just barely adequate to handle the flow of people fleeing from an advancing hurricane.

Ten years from now, the way things are going, that won't be the case. Unless proper planning is done—to keep people from crowding too close together on the coastline, and to provide dependable escape arteries that will not be severed by the rising water—we could have a disaster, in my opinion, that would cost this nation 20,000 to 50,000 lives—an unbelievable catastrophe!

I can visualize thousands of people stranded on inadequate roads in their vehicles—trying to get away, but completely immobilized—caught in gale force to hurricane winds, rapidly increasing in intensity, and surrounded by rising water. I shudder to think about it.

Q. What can be done to keep this from happening? How do you arrive at the optimum balance between hurricane vulnerability, population density, and adequate escape routes?

A. The President's Office of Emergency Preparedness is already considering the matter. From here, I would think that the OEP, with the Civil Defense and the Red Cross, would work down through the state and county levels to arrive at concrete proposals for specific localities.

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Q. Would it be possible for a disaster like that in East Pakistan, where a cyclone (hurricane) took 300,000 lives, to occur in the U.S.?

A. No. I can say that categorically. The circumstances there are unique—both in population concentration and terrain. The tidal storm surge drowned those people. They were densely concentrated on a series of very low-lying islands.

Even if the state of the forecaster's art were extended many hours beyond what it is now, you could not have evacuated significant numbers of those people to high ground in time.

The only sure way of giving them refuge is to do what my predecessor at the Hurricane Center, Gordon Dunn, recommended a decade ago—to build large earthen platforms on which the population could assemble during periods of rising water.

Q. How about Corpus Christi during Hurricane Celia last year? Was it fully prepared?

A. Corpus Christi was completely buttoned up and ready for any kind of storm that might have occurred. I have never known any town to be more thoroughly prepared for a hurricane.

Q. There was quite a bit of damage though, wasn't there?

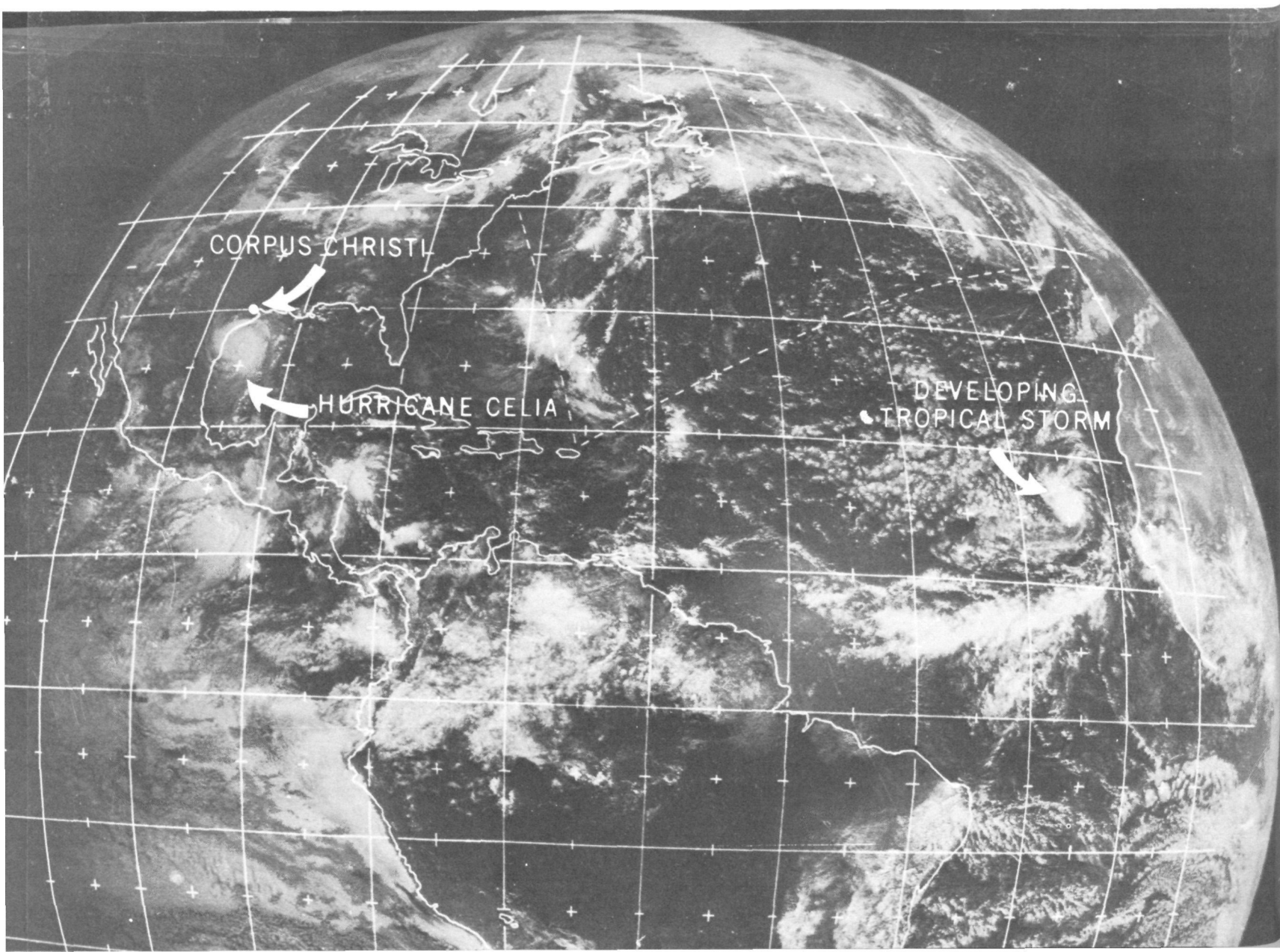
A. Yes, there was—estimated at 454 million dollars, fifth highest on record in the U.S.—but there was very low loss of life, with 11 people killed in Texas.

Celia was a very unusual hurricane. It was very dry, for a tropical storm; it intensified extremely rapidly as it approached the coast—with a drop of over 40 millibars in 14 hours—and its strong winds were in the left semicircle instead of the right, as it passed inland. Lastly, most of the damage was caused by wind, rather than water, and most of the destruction occurred during a gust of less than half-a-minute's duration, when the anemometer at the airport registered 140 knots (161 miles per hour).

That one gust collapsed a new airplane hangar and flattened a trailer park with several hundred mobile homes. Looking at its effects from a helicopter, as I did, the appearance was like giant clawmarks on the ground.

Based on my observations and some analyses that Professor Ted Fujita of the University of Chicago is making of photographs of the destruction, it appears that the true velocity of that gust was probably much greater than 161 miles per hour, perhaps as much as 200. The probability is that the anemometer—a cup type—was incapable of winding up fast enough to measure it.

This points up the fact that the National Weather Service might do well to install sonic anemometers in storm-prone areas, so we can measure these forces and design our structures accord-



ingly. The Japanese have learned to manufacture these at less than twice the cost of our cup-anemometer systems. I think we should have them installed at all coastal stations.

Q. Mobile homes are especially vulnerable to windstorms, aren't they?

A. Indeed they are. In a hurricane such as Celia, there is nothing that can save a house trailer. Planning officials should insist on evacuation of mobile-home residents when a hurricane is theatening. They simply aren't safe during a hurricane, much less a tornado. Officials should require also that storm shelters be nearby. And house trailers should be strapped down to concrete holdfasts, so they don't become lethal projectiles themselves.

In Corpus Christi, there was an incredible mincemeat of destruction of mobile homes, trailing literally miles downwind from the trailer park that was obliterated.

Q. What happened to the people who lived in those trailers?

A. Corpus Christi had evacuated them. I don't think anyone remained in a trailer in that part. If there had been, that person almost certainly would have been seriously injured or killed. Invariably, there are flying timbers that will go right through a trailer with the greatest of ease.

Q. Would it have been possible for trailer owners to have hooked up and gotten away to safety?

A. I don't recommend it These are the kinds of things that could clog evacuation routes and impede passenger vehicles carrying greater numbers of people.

Q. How would you advise owners of mobile homes to avoid hurricane danger, particularly older people on fixed incomes with no other place of residence than their mobile homes?

A. In a coastal area subject to hurricanes, I would locate it at least 10 miles inland, at least during the hurricane season. Second, I wouldn't think of leaving my trailer without straps attached to holdfasts imbedded in concrete. Even outside of the hurricane season, there are severe thunderstorm winds every week that wreck mobile homes.

Q. Does the Hurricane Center offer advice to communities on ordinances and building codes for storm safety?

A. That is one of our most important functions. We try hard to maintain as much competence on that as possible. I consult regularly with an expert structural engineer.

Each year, this center is visited by hundreds of people from all over the hurricane zone seeking information and advice on hurricane probabilities and destructive potential. They frequently ask for advice on where to get sound information—building codes and that sort of thing. And we give it to them.

An ATS-3 satellite picture, taken during the morning of August 3, 1970, showed Hurricane Celia heading for Corpus Christi, Texas. The storm center struck the city that afternoon, causing 11 deaths and an estimated 454 million dollars' damage—the fifth highest hurricane-damage figure in U.S. history. "Corpus Christi was completely buttoned up and ready for any kind of storm that might have occurred," Dr. Simpson says. "I have never known any town to be more thoroughly prepared for a hurricane."

Q. Would you be in favor of setting up hurricane buffer strips along the shore in storm-prone areas, in which a limit was set on the density of population that would be allowed?

A. Where practical, I certainly would endorse that. In fact, I have recommended it to a number of communities that sought advice here. There is an enormous decrease in wind force as a hurricane moves inland. And the storm surge usually doesn't extend inland great distances. Most of the loss of life and damage could be averted if densely populated and heavily industrialized areas were not permitted within two or three blocks of the shore. Then the buffer strip could be used for public parks, so that a community could pridefully point to an intelligent combination of storm safety and recreation.

Of course, it's too late for that in some places. I can hardly imagine Dade County working out an agreement with Miami Beach to tear down all those high-rise apartment buildings and luxury hotels to convert the area into a park.

Q. There has been a suggestion to erect offshore barriers to lessen the impact of hurricanes and tidal storm surges. What's your reaction to that idea?

A. Horror. I can't think of a single excuse for such a barrier to hurricanes, except where the idea is to provide a harbor where ships are moored, to protect them against wave action. But the idea of a barrier to hurricane tidal surges is completely wrong. There has been a misconception for years that a reef just offshore offers magic protection to residents of the inner coastal area.

Nothing could be further from the truth. Such a barrier can extend or amplify the storm surge—increasing the depth and/or area of the inundation. The storm surge is an accumulation of water resulting from stresses of wind on the surface. These forces transport the water toward the coastline regardless of reefs and breakwaters. In fact, these "impediments" may actually foster the transport of water by causing premature breaking of waves passing over them. A breaking wave transmits mass, whereas a nonbreaking wave in the deep ocean does not.

Q. What is the principal cause of death from hurricanes?

A. Drowning, by a ratio that is probably about nine to one. We don't have exact figures on it, but that's fairly close.

People get trapped by the storm surge; they try to wade to safety, and they drown.

Others drown because they foolishly try to enjoy a swim in the heavy surf generated by hurricanes. Powerful undertows and riptides can sweep even strong swimmers to their deaths.

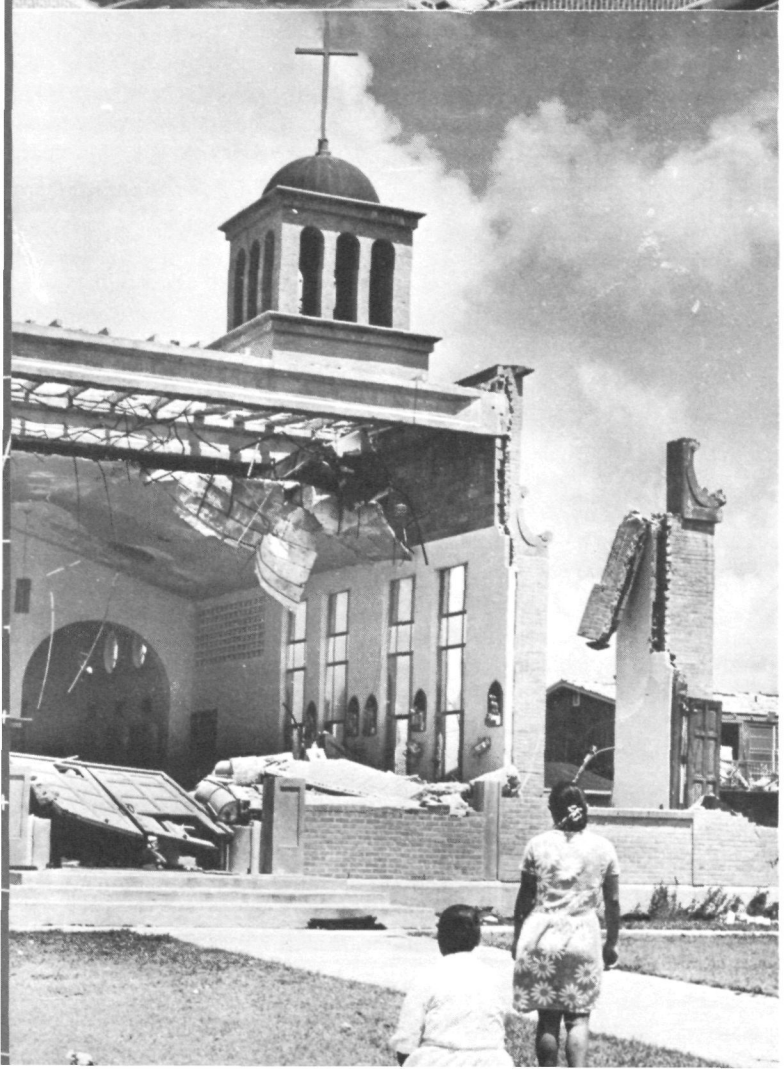
Q. Does this mean people shouldn't worry too much about wind hazards from hurricanes?

A. No indeed. People frequently are killed during hurricanes by the tornadoes that accompany them. There were at least 49 confirmed tornadoes during Beulah. Tornadoes, as you know can explode a house and send wood through metal.

Even flying debris from hurricane winds of less than tornado force is an important cause of deaths. Celia's winds sent pieces of board through tree trunks. Such projectiles are carried at frightful speeds and usually with a twist which makes them act like corkscrews.

Then, an indirect wind effect is electrocution—deaths from fallen power lines. These may be even more common than from flying debris. Power companies try to anticipate this and shut off the current to various sectors of their grids as they go down. But all too often the power is still on when lines are down. Unwary people then step on them or try to pick them up to clear a path and are electrocuted.

continued



Celia was a very unusual hurricane. Most of the damage was caused by wind, rather than water, and most of the destruction occurred during a gust of less than half-a-minute's duration, when the anemometer at the airport registered 161 miles per hour. Photos by Corpus Christi Caller-Times.

Q. What about property losses from hurricanes? Any new developments to reduce the risk?

A. It used to be that you could get insurance only for wind damage, but not for water damage. Eighteen months ago, however, the Federal Government began subsidizing insurance companies in a fashion that allows them to cover water damage, too. I have it on my house in Florida—$21,000 worth for $150 a year.

Q. There are times when you don't pin the label hurricane on certain storms even though they have hurricane-force winds of more than 73 miles an hour. Why is that?

A. From a practical point of view, it's important to distinguish hurricanes from other storms of similar wind force for this reason:

The hurricane is a marine storm. Its initial hazard is to vessels at sea. It differs from other marine storms in that its energy is very closely knotted around a circular core—the eye. The radius of maximum winds is rarely more than 15 nautical miles.

This tight circle of wind produces a disorganized, chaotic sea, with waves sent out in one direction interfering with waves moving in another direction. Shipmasters know that if they get in front of such a storm they are likely to be completely helpless before it, and have to heave to and ride it out as best they can.

Other storms with similar force winds, but not organized into a tight spiral, can be navigated safely because the waves are much farther apart and relatively innocuous to ships.

Because shipmasters frequently will go days out of their way to avoid a hurricane—at considerable expense—but will sail right through these other storms, we think it's important to make the distinction, and will continue to do so.

We do provide warnings to vessels about these nonhurricanes —or "neutercanes" as I call them—but we just don't give them the status of a named storm or hurricane, unless they threaten a populated area.

Q. As better and faster computers come on the line, do you think there will ever come a time when hurricane forecasting will be completely computerized?

A. No. I do foresee a day when the forecaster will be surrounded with a galaxy of numerical information, over which he will preside, and from which a forecast will come logically from a procession

Robert H. Simpson first encountered a hurricane during his childhood in Corpus Christi, where he and his parents were exposed to the full fury of the great storm of 1919 that lashed the Texas coast and inundated low-lying areas. Amid hurricane-force winds, and with water rising 14 to 16 feet above street level, the Simpson family managed to swim to higher ground and the safety of the city courthouse.

Since that day, tropical cyclones have been a source of fascination, often leading him to travel out of his way to get close to the center of hurricanes in order to study their behavior.

In addition to a number of surface encounters, Dr. Simpson has been on innumerable research flights into hurricanes. The first was from Panama in 1945. He participated in a series of special huricane research flights through and over the September 1947 hurricane that swept over Florida and Louisiana. Later, as Director of the National Hurricane Research Project and then as Director of Project Stormfury, he took part in many more hurricane missions.

A graduate of Southwestern University with a B.S. degree, he earned his master's in physics from Emory University and did further graduate work at the University of Chicago, where he was awarded his doctorate in geophysical sciences.

He joined the Weather Bureau in 1940 and served at Brownsville, Texas, Swan Island, New Orleans, and as meteorologist in charge at Honolulu. He has held several headquarters post during assignments to Washington, D.C. From 1955 to 1959, he was Director of the National Hurricane Research Project and became the first director of Project Stormfury when the Department of Commerce-Department of Defense hurricane modification study was established in 1962. He was appointed Director of the National Hurricane Center at Miami in 1967, after two years as Associate Director of the Weather Bureau.

In recognition of his outstanding contributions to the study of hurricanes, Dr. Simpson received the Department of Commerce Gold Medal in 1962.

His wife is Dr. Joanne Simpson, Director of ERL's Experimental Meteorology Laboratory at Miami, and herself a former director of Project Stormfury.

of data. But there always will be at least an override function for the forecaster.

If, for example, a populous area—a big city—is just on the outside of the sector of predicted landfall, the forecaster will extend his warning to include that area. These adjustments to take care of vulnerability factors not involved in the meteorological forecast will always have to come from the good common sense of the forecaster.

Moreover, I don't expect to see in my lifetime the exactness in prediction for 30 hours to eliminate the need for human judgment even in a meteorological sense.

Q. How about your new numerical model for prediction of hurricane storm surges—the one produced by Chester Jelesnianski of the Weather Service's Systems Development Office? Are you enthusiastic about this?

A. Yes. We don't think our subjective judgment as forecasters can improve on it. We plan to use it exactly as he presented it to us. It's not infallible, but it's better grounded physically than anything we ever had before. And it will be improved. He is continuing to work on it.

Q. Is it to be operational only for the Gulf of Mexico?

A. We'll also have it for the Atlantic coast up to Long Island this year.

Q. A sociological study by Mississippi State University reported that more than a fourth of the people in the path of Hurricane Camille ignored warnings to evacuate. What can be done about reactions like that? Should people be forcibly removed from their homes?

A. I doubt that it would be constitutional, although attorneys I've asked about it are uncertain. I think the only real cure for complacency is the annual hurricane-preparedness conference in each community—conducted in a way to drive home to each resident the potential hazards of a hurricane and the actions he should be ready to take. We hold these conferences systematically in areas of high hurricane occurrence.

Q. What do you regard as the biggest obstacle you have to overcome in these conferences?

A. I think the most dangerous attitude we have to contend with is that of a person who has experienced a near-miss from a hurricane. If he has been warned that a hurricane will strike him and it misses by 20 miles—and all he sees are a few palm fronds and shingles blown off and a couple of inches of water in the street—why, he's likely to conclude that a hurricane is a highly overrated instrument of destruction.

And the next time he's warned, he's liable to stay put and watch the fun. Some people did that during Camille, and it was the last fun they saw.

Q. Do you think some of them may have been overwarned in the past?

A. That's a perennial concern in this business. Hurricane forecasting is a double-edged sword. If every time you see a storm that's a potential threat to a populated area you alarm the people and stir up a lot of headlines, when the actual danger is not too great—why, soon they will stop listening to you altogether.

Let me give you an example—something that Gordon Dunn faced in 1966. There was a little storm that marched down the Florida coast from the northeast to within 50 miles of Cape Kennedy, then made a U-turn and headed back northeast.

Even when it got within 50 miles, Dr. Dunn never called for warnings to be issued. He felt they weren't required. It was a touchy situation. But he felt he had enough continuous information on it and that his bulletins had aroused enough awareness among the people that it wasn't necessary to go into the actual warning stage.

So he was able to avoid the costly and strenuous preparedness that an official warning would have triggered. And he got a great deal of praise for his good judgment. Yet if that storm had become a hurricane and blown over a few rockets on their pads and killed a lot of people, it would have been a different story.

That's why this job is so challenging. You continually have to make decisions of that kind.

How are you going to play it? You can't play it the simplistic way of always warning all people of all provocations.

If you do, they'll never listen to you because they won't be disturbed enough by your warnings.

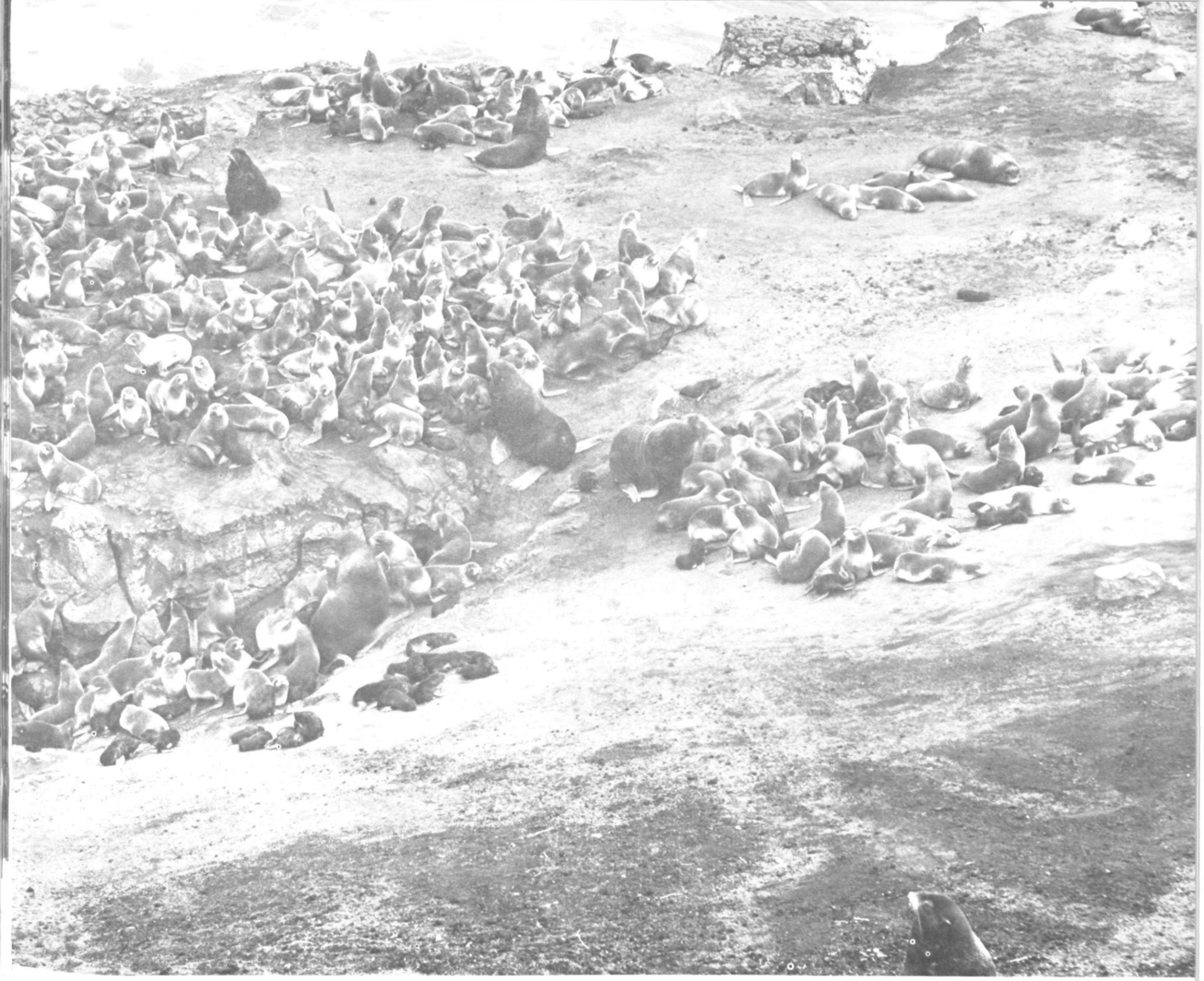
But you can't afford to gamble beyond the state of the art.

Where you draw the line is my job—and I like it very much. □

Under National Marine Fisheries Service management, the Pribilof seals have come back from near extinction.

A THRIVING HERD

BY JOHN A. GUINAN



Bull fur seals guard their harems on the rocky shore of St. Paul Island.

On the grim, mist-shrouded Pribilof Islands off the coast of Alaska, an annual ritual that predates recorded history is taking place once again.

The Northern Fur Seals have arrived at the rookeries on these lonely islands. The snowdrifts along the rocky beaches and rough volcanic hillsides have not melted completely when, in late May and early June, the big breeding bulls begin to appear. Heavy with fat from the long winter's feeding, belligerent and full of fight, the bulls or "beachmasters" lumber ashore. Each establishes his individual territory—about 30 to 50 feet in diameter—which another bull enters at his peril.

Mature male or "bull" fur seals are much larger than the females, or "cows." The fur seal cows average about 100 pounds in weight, but the great breeding bulls weigh from 400 to more than 600 pounds. The young of these fascinating creatures are called "pups."

Soon it is summer on the tiny islands where no tall tree grows, but where for this brief season hundreds of varieties of wildflowers of rare color and beauty burst into bloom.

About mid-June, the cows begin to arrive. Until this time, once their territories had been established, the bulls have slept or rested from their long sea journey. When the contest for their harems begins, however, there is no rest for the big beachmasters. Polygamous to an amazing degree, each gathers in as many docile cows as possible; the number varies from one or two to a hundred, but the average is about 40. Day and night, the air is filled with the bleating of females and young, and with the roars of the mighty males as each bull defends his harem against all comers. Battles between males are savage. From now until the end of the breeding season, the bulls live without food and get little sleep, gradually losing the layers of fat with which they came ashore.

Almost as soon as the harems are formed, the pups conceived the year before begin to appear, and soon after a pup is born the mother is bred again. One pup per cow is the rule, and the young are carried for an entire year before birth. Not all cows bear young each season; the proportion is about 80 percent.

The pups are precocious, their eyes wide open. They are active and have a coat of hair. It will be some weeks before any fur appears. They are entirely dependent on the mother's milk for food. The cow generally stays close to her youngster for several days, then leaves to go to sea for food. The mother may be away for a week, her trip taking her as far as a hundred miles from the rookery, but when she returns, the pup makes up for lost time. It takes on several times more milk than would a human infant of the same body weight—up to a gallon of rich, creamy milk at a feeding. The little stomach swells like a toy balloon as the pup drops off for a long sleep. The mother seal will feed only her own pup and, despite her lengthy absence, the miles she travels, and the thousands of pups in a rookery, she finds her own.

Baby fur seals venture to the water at about four weeks. Even though they can swim at birth, they have very little endurance. Their first trips to the cold water are taken with trepidation.

The cow seals nurse their young for about three months, and no human disturbs them. By now the weather is taking a turn for the worse, and the pups are left abruptly to shift for themselves. Early mortality is high. Many pups succumb on the island before migration; others are prey to killer whales or big sharks; still more are lost in storms at sea. Yet more than enough young seals survive each year to keep the herd at its maximum healthy size.

Around the edges of the breeding rookeries range the younger bulls, varying in age from six to eight years but not yet strong enough to compete with the fully matured beachmasters. Now and then they may steal a wayward wife or two, or even take over the harem of a disabled monarch. But most of the younger bulls await the end of the active breeding season when the young un-

continued

St. Paul is home to about 400 Aleuts. Compared to many towns in Alaska, it has excellent physical facilities—reliable electrical service, pure water, a volunteer fire department, and a sewer system.

bred females appear on the shore to join their first harem.

And while all this activity goes on, the younger male seals, up to six years of age—known as "bachelors"—congregate in their own area nearby. It is from these males that the annual harvest of fur seal skins is taken, primarily from three and four-year old animals. Because the number of males and females at birth is approximately the same, and because the breeding bulls are so polygamous, many of these bachelors are surplus to maintaining the population of the herd.

Removing bachelors from the hauling grounds is comparatively easy and does not disturb seals in the breeding rookeries. The weeks from late June until early August find the Aleut sealers on the hauling ground each morning at daybreak. The bachelor seals are driven a short distance inland from the beaches and sorted into progressively smaller groups or "pods," until only those to be harvested remain on the grounds. The seals are dispatched by a single blow to the head with a long club, immediately followed by sticking the heart. It may look cruel, but it does render a quick death. In fact, no quicker or more efficient way has been found to kill the animals in spite of a great amount of research over the past three years to find another method. The National Marine Fisheries Service, which administers the Pribilof Island Fur Seal Program, continues to seek an alternative method of dispatching the animals and this year has a six-man team of consultants referred by the American Veterinary Medical Association studying the problem on the islands.

After the pelts are taken, they are transported to a processing plant on the islands where they are cooled and washed, and the fat or blubber is removed. The pelts are then cured in brine; when this process is complete, they are packed in wooden barrels.

Fifteen percent of all skins taken by the United States go to Japan and another 15 percent to Canada, under terms of an international treaty. In return for a share of the skins, Japan and Canada refrain from what is called "pelagic" sealing—that is, taking seals at sea. Pelagic sealing is a wasteful process, because the sex or age of seals is most difficult to determine when they are in the water, and because many animals are merely wounded and lost.

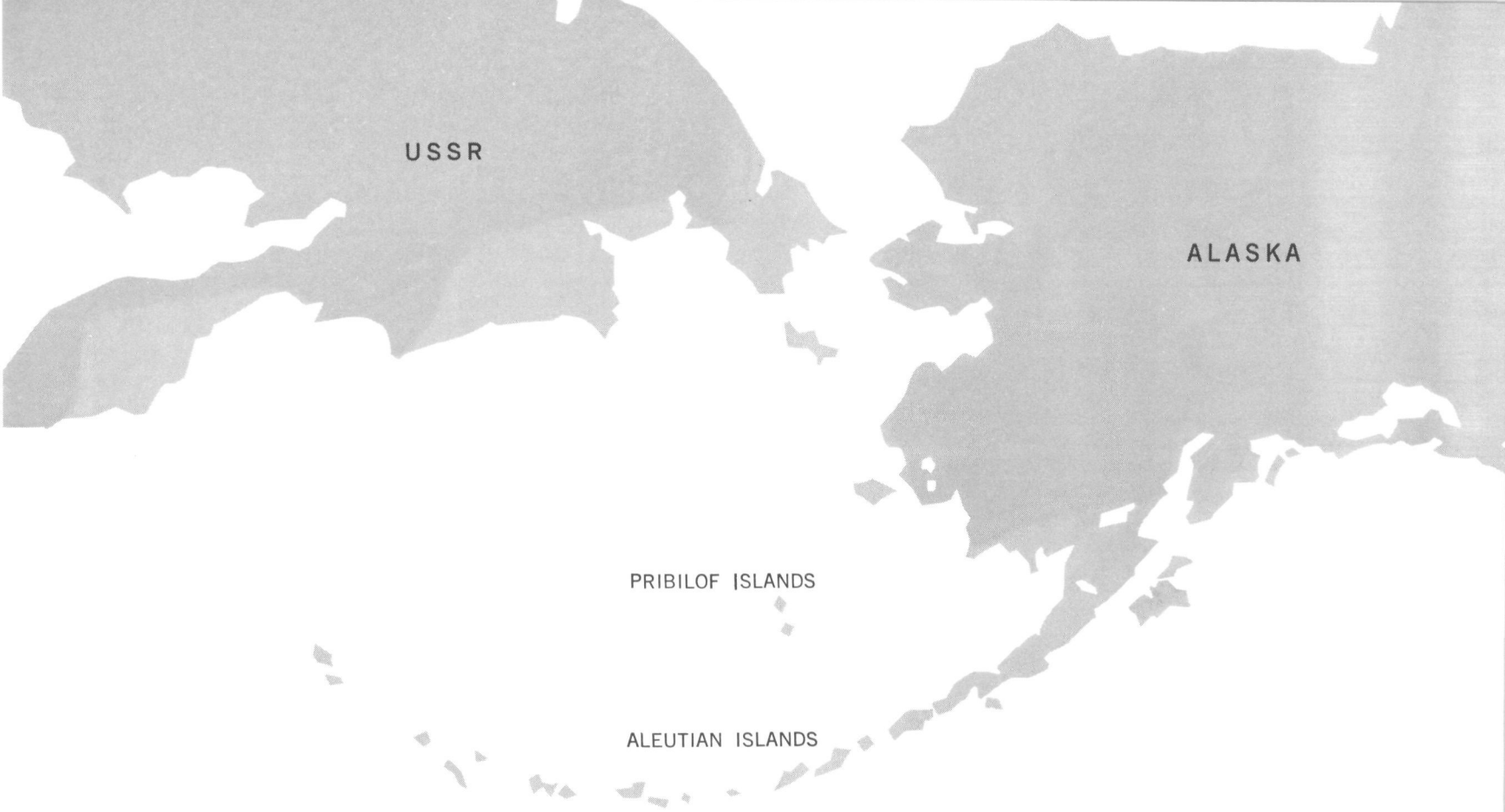
The Soviet Union harvests fur seals on the Commander Islands and Robben Island and has the same percentage arrangement with Japan and Canada. Representatives of the four nations meet annually under terms of the Interim Convention on the Conservation of North Pacific Fur Seals.

The Alaska fur seal herd, the world's largest, today numbers some 1.3 million animals. Early in this century, the seals faced extinction as the population declined to about 200,000. Since then, under the sound wildlife management practices of the NMFS (formerly the Bureau of Commercial Fisheries), the herd has increased and stabilized. Scientists determine how many seals can be taken each year without endangering the population, and the kill is limited to that number. The restoration of the herd has been hailed throughout the world as an outstanding achievement in wildlife management and conservation.

NMFS scientists and technicians travel to the Pribilofs to supervise the annual harvest. They join the year-round and temporary Aleut employees who work on all phases of the harvest. Sealing and related services are the only real employment available to the people of the islands.

The inhabitants are Aleuts, a people said to have been taken to the Pribilofs to harvest seals for the Russians shortly after the islands were discovered. They are generally somewhat shorter than their fellow Americans in the "Lower 48" and somewhat stockier in build. They are not Eskimos, and maintain they are a separate race. Some of the present residents can trace their ancestry back for 180 years; more than 95 percent were born on the Pribilofs.

St. Paul, the larger of the two inhabited islands, is home to about 400 residents. Compared to many towns in Alaska, it has excellent physical facilities—reliable elec-



trical service, pure water, a volunteer fire department and a sewer system. The frame homes are arranged on streets, and new homes may soon outnumber the older residences.

The Aleuts are keenly aware of the importance of sealing, because it is their primary source of employment except for the relatively few service and maintenance jobs. There is no agriculture. St. Paul has several local businesses. There are four cafes, or refreshment stands, two movie houses, several taxis or rental cars, and one intermittent barber shop.

Since 1962, all workers employed by the United States have received standard government wages in accordance with the work performed and the period for which they were employed.

The Aleuts are full-fledged U.S. citizens who vote in local, state, and national elections. They all speak English, pay taxes, and young men are subject to the draft. Elementary school education is available, but for a high school education youngsters must go to the mainland.

Residents of the Pribilofs do not yet have telephones or television, but practically every family has at least one short-wave and long-wave radio. Many homes are equipped with citizens-band short-wave radios which substitute for telephones, except that there is no privacy. With these radios, they can communicate with each other on St. Paul and with friends and relatives on St. George, the other occupied island. The story is told of an Aleut lady who wanted to have a semi-private chat with a friend at the other end of the village via the citizens-band radio, so she whispered.

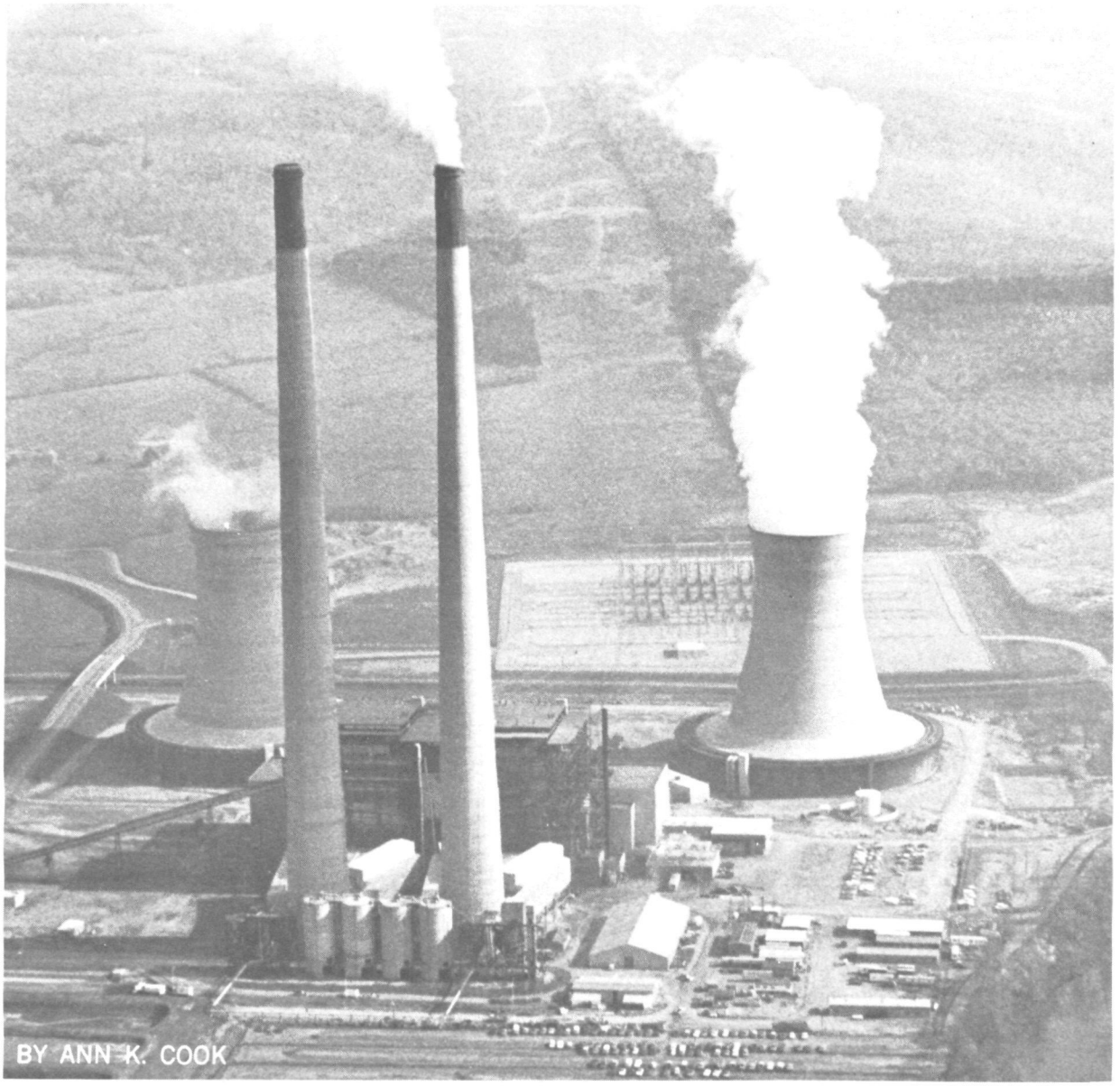
A small herd of wild reindeer roams St. Paul Island; and bird lovers come from all over the world, equipped with cameras and binoculars, to see the tufted puffins, the murres, the kittiwakes, the pelagic cormorants, and many other species.

And each year, the seals return, in a migration that has continued for eons. □

THE TRUTH ABOUT THE U.S. FUR SEALS

FICTION	FACT
The U.S. kills baby seals on the Pribilof Islands.	The U.S. does not kill baby seals on the Pribilofs or anywhere else. Misleading advertisements have used pictures of a Canadian harvest of a different species of seal.
The U.S. seal harvest takes place on the ice.	The U.S. harvest takes place on land a short distance from the rookeries where animals can be carefully selected for sex and age.
Clubs are used because it's the cheapest way to kill the animals.	Scientific evidence has shown that clubbing and sticking the heart with a sharp knife is the quickest and most humane way known to dispatch the seals.
At the rate we are killing them the last seal will soon be gone.	The Pribilof Island seal herds are scientifically managed to maintain the herd at its stabilized population of about 1.3 million animals. That is close to the number which will provide the greatest annual harvest.
Seals are skinned alive.	There is no possibility that the animals could be alive or could recover after being struck with the club and the heart stuck with a knife.
Clubbing and stabbing are cruel.	The method is consistent with current humane slaughter practices. The United States refuses to use a less effective method merely for the sake of appearances.

IN PURSUIT OF THE PLUME



BY ANN K. COOK

Photos by John Roseborough

In western Pennsylvania, a NOAA team tracks the path of air pollution particles with balloons, bubblers, and a helicopter.

In the western foothills of the Allegheny Mountains is a modern colossus, twin towers soaring 1000 feet in the air, flanked by massive hivelike forms, themselves 370 feet tall. Its monumental proportions recall the wonders of the ancient world, built to placate gods or glorify pharoahs.

But this is Conemaugh Generating Station, a 20th century temple of electricity, producing power for the consumers of the eastern United States. It is also one subject of a study, conducted by NOAA's Air Resources Laboratory, Raleigh, N.C., which is sponsored by the Environmental Protection Agency. In this study, the effectiveness of tall stacks in dispersing pollutants in the atmosphere is being examined.

After motor vehicles, coal and oil-burning electric power generating stations are the next greatest source of atmospheric pollutants in the United States. As demand for power grows, power production in this country is expected to increase as much as fivefold over the next 30 years, releasing to the atmosphere added millions of tons of contaminants.

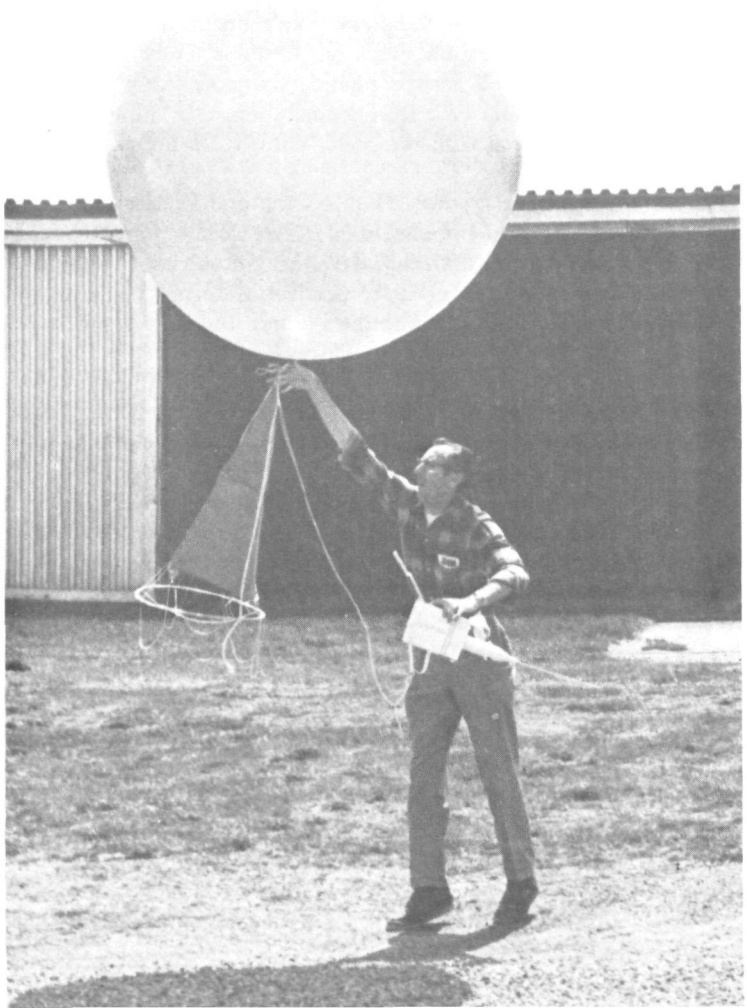
By the year 2000, the global emission of sulfur by power plants may exceed the estimated 142 million tons produced annually by natural processes, thus becoming the primary source of sulfur contamination.

Well aware of the problem, the power industry is actively seeking ways to reduce its output of pollutants. More efficient precipitators are removing large quantities of particulate contaminants, before boiler effluent is released to the atmosphere. In the past decade, the industry has been increasing the height of smoke stacks, in the hope of maintaining reasonable air quality at ground level near the plants. The average height of stacks built in 1960 was 240 feet; by 1969, it had climbed to 600 feet, with the tallest exceeding 1000 feet.

Just how effective such tall stacks are in reducing air pollution, no one really knows.

According to NOAA scientists participating in the present study, any source of pollution that is provided with a chimney, even of moderate height, will produce lower local ground-level concentrations of gases and particulates than would the same source without a chimney, especially in the immediate vicinity. By discharging

(Opposite page) The twin stacks of Conemaugh Generating station tower a thousand feet over the western Pennsylvania terrain. (Left) Instrumented helicopter begins a temperature profile. (Below) Joseph Smith prepares for one of the project's two daily radiosonde flights.



pollution high above the earth's surface, the tall stack gives the atmosphere more chance to dilute them. But under certain atmospheric conditions, pollutants are insufficiently diluted and may be brought down to the earth's surface in excessive concentrations.

Although considerable data had been gathered in past years on dispersion of contaminants from lower stacks at smaller plants, the results cannot always be applied to high-capacity, tall-stack installations.

Therefore, in 1967, the former National Air Pollution Control Administration—now incorporated in the Environmental Protection Agency—began a five-year field study of the local extent and effects of power plant emissions from tall stacks. Known as the Large Power Plant Effluent Study (LAPPES), the project is conducted in western Pennsylvania with the cooperation of the Pennsylvania Department of Air Pollution Control and the Pennsylvania Electric Company.

The study as a whole seeks to define and model the weather conditions that bring tall stack effluents to the ground, the magnitude, frequency, and area of these occurrences, and the effects on vegetation. The meteorological portion of the study, conducted by NOAA personnel on loan to EPA, is designed to determine the rise of the effluent "plume," its horizontal and vertical dispersion under varying meteorological conditions and the magnitude, area, and frequency of sulfur dioxide concentrations at ground levels produced by emissions from tall stacks.

The Pennsylvania region where the field investigation is being conducted lies on the western slopes of the Alleghenies. Creeks and rivers thread among the forested, rolling hills, and the deer population makes the area a mecca for hunters. The principal agricultural product is Christmas trees. A major resource lies under the land—coal.

Abundant coal and proximity to eastern urban areas make the region ideal for power generation. And it now has the largest complex of coal-burning power stations in the United States, fed from coal mines directly under or near the plant sites. The three newest stations—Keystone, Homer City, and Conemaugh—are located east-northeast of Pittsburgh. These three tall-stack plants, and two older plants nearby, produce a total of more than 47 million megawatt hours (470 billion kilowatts) annually, exceeding the yearly production of all but eleven nations in the world. When they reach full production, the three new plants will consume 42,000 tons of coal and emit close to 2000 tons of sulfur dioxide gas into the atmosphere every day.

During the field study, data has been collected at each of these three power stations. At the beginning of the project, data-gathering periods were scheduled in all seasons of the year but, since 1968, experiments have been conducted only in the spring and fall—seasons in which there is a good chance for meteorological conditions of interest to the project. The autumn 1971 data-gathering period is slated to be its last.

Each data-gathering period means a month of hectic activity from sunrise to sunset for the four NOAA men involved. They are LAPPES project meteorologist Frank A. Schiermeier, Ralph Soller, Ernest Tillotson, and Joseph Smith—the latter borrowed for the second half of the experimental period from the Laboratory's staff at Raleigh, N.C., replacing Howard L. Moneypenny, also from Raleigh.

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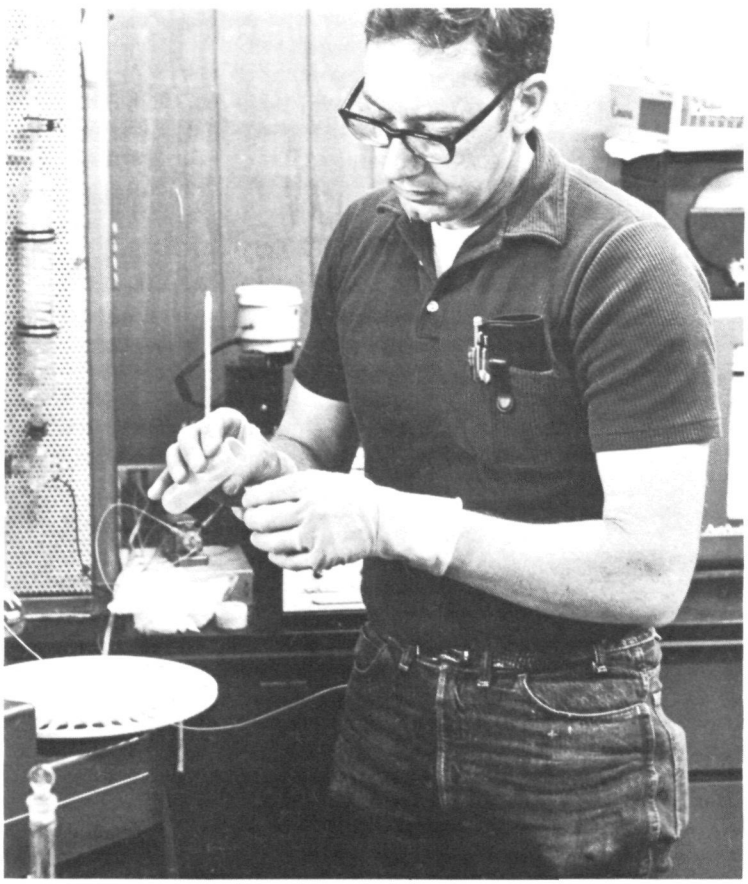


(Top) Ralph Soller set out one of ten portable "bubblers" that collect samples of sulfur dioxide at the ground. (Bottom) In the afternoon, Soller analyzes the day's 60 surface air samples. Part of each sample is poured in a test tube, and an automatic analyzer produces a record of the sulfur dioxide content.

Together, they compile a detailed daily record of the changing local meteorological conditions and, using sulfur dioxide as a tracer, follow the plumes from the tall stacks as they spread and reach the ground. To do the job, they use an instrumented helicopter, radiosondes, pilot balloons, and portable air samplers.

Schiermeier and a contract pilot arrive shortly after dawn at the century-old farmhouse that serves as the project's headquarters. The building, at Indiana, Pennsylvania's Jimmy Stewart Airport, has in its "back yard" a small meteorological network that provides continuous data on surface wind direction and speed, solar radiation, air temperature, relative humidity, and rainfall.

Schiermeier will spend the morning in the helicopter, following the plume from one of the tall-stack power plants, as the aircraft's instruments measure and record sulfur dioxide, pressure height, humidity and temperature. Before liftoff, he inserts the sulfur-dioxide analyzer into the plane's instrument rack, mounted in what was the left passenger position, so that Schiermeier, seated at the right, can continuously monitor the readings. Then the helicopter heads for the power plant, where the first job of the day is to circle from the surface up to 3500 feet, gathering an early morning temperature profile.

At headquarters, Tillotson and Smith—the balloon team—launch the 6 a.m. radiosonde and track it to 10,000 feet, gathering data on pressure, temperature, humidity, wind speed, and wind direction. Then they, too, head for the power plant, but the balloon team makes the trip of some 25 miles in a government station wagon. In the back of the wagon is a supply of pilot balloons and helium cylinders. Tillotson and Smith will spend the morning in a field across the road from the power plant, launching pilot balloons every half hour till noon, and tracking the balloons with a pair of theodolites. By following these small uninstrumented balloons as they rise through the atmosphere, and recording the changes in azimuth and elevation angle, wind speed and direction—which govern the plume's dispersion—can be determined.

In the helicopter, Schiermeier completes the temperature profile near the stacks and then begins to track and measure the effluent plume emitted from the stack. With the instrument rack at his side, detailed topographic maps on the floor, notebook and pen in hand, he visually follows the plume. To make the plume easier to see, the Pennsylvania Electric Company allows a limited amount of flyash to be released with the boiler effluent during experimental periods.

The tops of the Keystone, Homer City, and Conemaugh stacks are above the height of the cool stable layer of air normally found near the surface in the morning after the ground cools during the night. While this cool lower layer persists, it forms a barrier preventing the plume from reaching the ground. But as the sun warms the earth and air, the lower layer warms and mixes with the layer above, forming a single layer. At this stage, the formerly well-defined plume breaks up and is brought to the ground. Just where it reaches the surface depends on the prevailing wind and other atmospheric conditions.

While the plume is still trapped above the cool air, the helicopter executes three cross-sections of it, 2½, 6, and 10 miles from the stack. Flying crosswind at a constant speed of 50 miles per hour, and beginning about the mid-level of the plume, the helicopter makes successive traverses at 200-foot intervals until reaching the top; then starting again from the mid-level, it crosses back and forth to the bottom.

Two methods—the sulfur dioxide readings and the eyes—are used to determine whether or not the helicopter is in the plume. Visual tracking is often difficult. Sometimes, Schiermeier says, "We lose the plume in the valleys or in the haze. You turn around to see where the stack is, and you can't see it. So you go back and try again." But he has followed plumes as far as 40 miles from the source.

Once the shape of the plume has been defined, Schiermeier

contacts the fourth member of the team, Ralph Soller, by radio.

In the back of his four-wheel drive truck, Soller has 10 portable "bubblers" and batteries to power them. Used to collect samples of sulfur dioxide at the ground, the bubblers each collect six consecutive 30-minute air samples.

From the helicopter, Schiermeier gives instructions on placement of the bubblers for this day's experiment, based on his estimate of where the plume will come to ground. Armed with a road map, Soller ranges the often unpaved back roads of western Pennsylvania, placing the bubblers where they can be expected to collect air samples with traces of sulfur dioxide that originated from the tall stacks at the power plant.

Each bubbler, housed in a metal toolbox, carries a notice that it is part of an air pollution test and includes the LAPPES headquarters address and telephone number. Soller places the boxes near the road and in exposed positions, but tries to conceal them from casual passersby. Since the field experiment began, not a single bubbler has been lost. One was picked up and returned to headquarters by a highway crew in the belief it was lost. The bubblers remain in position for three hours, then Soller retraces his route and collects them.

Having completed the early morning plume cross sections, Schiermeier returns in the helicopter to the plant for a second temperature profile. By this time, the aircraft is low on fuel and returns to the airport for more.

On the day's second flight, Schiermeier tries to follow the plume as it drops to the ground with the breakup of the once-cool lower layer of air. "We know we can't always be at the right place at the right time," Schiermeier says. "The most frustrating thing is when the initial breakup happens while we're back at the airport refueling."

The helicopter flies under the plume near the surface to determine the area affected by the sulfur dioxide in the plume. In what is fairly accurately described as a ground-level flight, the aircraft dips in and out among the valleys and ridges, skimming over or under power lines, seemingly flying through the treetops at times.

The second flight is completed about noon—some five hours of nearly continuous flight for Schiermeier and the pilot—and at the same time, the balloon team winds up its work near the power plant and returns to headquarters for another radiosonde launch—the final upper-air observation for the day.

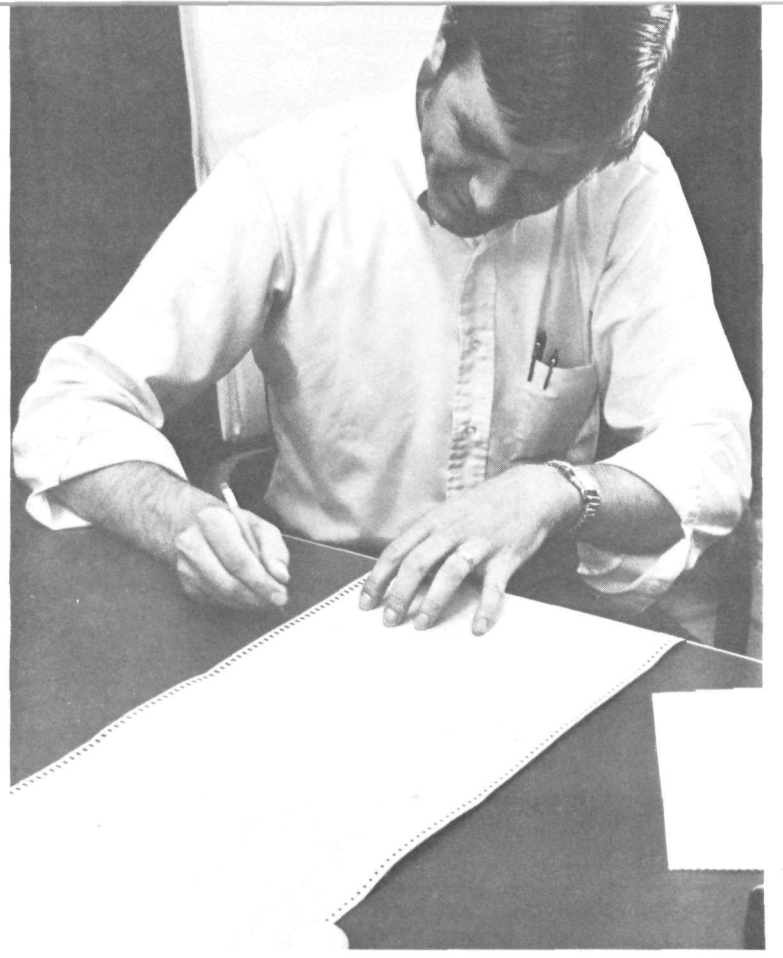
Back in his office, Schiermeier unrolls the data chart for the day. In flight, he has ticked off on the roll the points where the helicopter changed course or altitude, at the same time noting on a pad the heading, altitude, and geographic location. In the office, he double checks these notes and maps the day's flight course and the area covered by the plume. Later, when Soller returns, Schiermeier adds the bubbler sites to his map.

Now, Soller begins to analyze the day's 60 samples, using an automatic analyzer. Part of each sample is poured in a tiny test tube, and the tube is placed in the sampler turntable. Gurgling and clicking as it works, the analyzer produces, by a colorimetric process, a record of the samples' sulfur dioxide content. Analysis completed, Soller washes the "dishes" before going home.

The months between experimental periods are spent working up the data. The LAPPES field project does partial analysis of the data, but also presents it to others for use in developing and testing plume rise and dispersion theories. "When I was a student," Schiermeier recalls, "and used other people's data, I could always think of something they should have done but didn't. Now I'm on the other end. I know we're doing the best we can."

Much of the research based on LAPPES data is being done by NOAA scientists on assignment to the Environmental Protection Agency's Division of Meteorology at Raleigh, N.C.

Francis Pooler, Jr., and Lawrence E. Niemeyer of the Raleigh staff have made a preliminary evaluation of the effectiveness of tall stacks, based on available LAPPES data.



Frank Schiermeier checks data on pressure, temperature, humidity, wind speed, and wind direction recorded during the morning's helicopter flights.

"It is evident," they report, "that tall stacks help to reduce, or in some cases eliminate, occurrences of significant ground level concentrations that might be found with shorter stacks, but we should now point out some things that tall stacks cannot do. First, we don't think increasing stack height within any reasonable limits will significantly reduce the episodic ground level concentrations associated with the trapped plume, limited mixing layer situations; if emissions are increased, so will be the ground-level concentrations.

"Second, the study of washout by precipitation is only beginning. The effect of precipitation falling through the plume is to bring the sulfur dioxide closer to the ground. . . . There is increasing concern over the potentially deleterious effects of such acid rains.

"We have not yet considered the additive concentration that might occur when the maximum from one large source is augmented by a lesser background from another, nor have we made more than preliminary estimates of cumulative concentrations that could build up from a number of large sources in a region during an episode of poor ventilation extending over a period of several days.

"Finally, dispersing the tremendous emissions from many sources through greater and greater volumes of air does not remove one molecule of sulfur dioxide from the air. This removal entails formation of particulate matter, which in turn has unknown climatic effects. . . .

"In summary, we feel tall stacks are an unavoidably useful palliative to aid in reducing the more evident effects at ground level of emission of larger quantities of sulfur dioxide to the atmosphere, but the better long-range solution is to reduce the emissions themselves." □

Sea Grant marine advisory programs bring results of ocean research to those who use the sea, with

THE SHIRTSLEEVE TOUCH

BY GWIL O. EVANS

From the Yaquina Bay Coast Guard Station, two red lights pierce the night, warning mariners that gales are to continue. A mile up the highway, lights also gleam from an office in the county courthouse.

Inside, two men hover over an adding machine, pore through columns of figures, and sift stacks of business records. Only hours before, they were at sea, hauling up 140-pound crab pots and plucking the big red Dungeness crabs from them. Rising storm winds, not uncommon for the Oregon coast in March, had driven them back to Newport early.

One of the men is skipper of a 38-foot crabber; the other, a marine extension agent. This night, they work together preparing an application for a loan for the skipper's proposed new boat. The skipper had asked Jake to help because he respected his knowledge of fishing and his good business sense. Ordinarily, he'd do this sort of thing by himself, but he had known Jake for some time now and knew he could be trusted. Besides, he knew that Jake had had experience with National Marine Fisheries Service loan applications.

Jake is Bob Jacobson, an Oregon State University marine extension agent serving a marine clientele in three counties on the state's central coast. When he went to work in 1965, Jake was the nation's first full-time marine extension agent. Today, he is one of nine agents and specialists who make up the OSU Marine Advisory Program staff, part of the network of NOAA-supported Sea Grant advisory programs.

The Oregon State program was one of the first and is the largest marine advisory effort in the country. Others range from one- or two-man efforts such as that conducted by John Doyle in Alaska, to the interdisciplinary program conducted by Texas A & M University along the Texas gulf coast. In the northeast, Maine, Rhode Island, and Delaware have advisory programs of varying types. Elsewhere, other colleges and universities with NOAA Sea Grants are entering the marine advisory field.

Expansion of marine advisory programs in the late 1960's and the 1970's resulted from three major forces. First was the "piling up" of information from research in basic science and in applied technology. Years of research on ocean subjects produced a wealth of information that received varying degrees of exposure within the scientific community, but that frequently remained obscure from people who might apply it. Consequently, information continued to accumulate with no assurance of reaching an ultimate user.

The Commission on Marine Science, Engineering and Resources, for instance, cited the need for better dissemination of information to serve the commercial fishing industry. Reporting that users of marine fisheries resources took little advantage of knowledge generated by government agencies and educational institutions, it proposed "a concerted effort to bring the results of research and development to the actual users of the fisheries resources through a broad extension program involving all forms of extension media including personal contact."

Second among forces that led to creation of marine advisory programs is the critical nature of the problems that men face when they begin to use the sea as intensively as they want to use it today. There is both demand for information to help solve the problems and, on the other hand, there is an interest on the part of scientists who

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Gwil O. Evans is a marine science information specialist at Oregon State University.

want to know how they can help. A feedback system was required to convey information from marine user to researcher.

Finally, the Federal Sea Grant College and Program Act of 1966 helped focus these needs. The Act stated that marine resources "constitute a far-reaching and largely untapped potential of immense significance to the United States." It went on to call for developing manpower, facilities, and equipment necessary for exploiting these resources.

The Act authorized educating people in fields relating to development of marine resources. It supported necessary research programs while emphasizing practical matters relating to developing the resources. And, it encouraged "programs of instruction, practical demonstrations, publications, and otherwise" through marine advisory programs with the object of imparting useful knowledge to persons currently employed or interested in various fields related to the development of marine resources, the scientific community, and the general public. Thus, from the start, Sea Grant was given a "trident" of methods for solving problems of the marine community: research, teaching, and advisory programs.

The Sea Grant Act itself and the administrators of the Act (first the National Science Foundation and now the National Oceanic and Atmospheric Administration) asserted that advisory programs shared equally with research and teaching the task of achieving Sea Grant goals. But if encouragement of advisory programs has been uniform, the shape that the advisory programs have taken is diverse. Reasons for this diversity are several. The shape a marine advisory program takes is influenced by the physical nature of the area it serves. How long is the coastline? How wide is the continental shelf? What minerals are present? What kind of weather prevails? Similarly, economics influence the advisory program. What is the major marine industry? Is it big business or small enterprise? Is it new or well-established? The sociopolitical nature of the area to be served is an important influence, too. Is there a willingness to accept change? What is the educational level of the potential client of the advisory service? Does the local decision-making structure understand and support the advisory effort?

Oregon State's Marine Advisory Program serves as one example of how marine extension educational programs are emerging. Although extension home economists had taught homemakers how to use Oregon seafoods since the early 1940's, the first serious marine extension project began in 1961 with oystermen in the Tillamook Bay area, on Oregon's north coast.

The oyster program concerned production, processing technology, and finance. Bill Wick, now head of the OSU Marine Advisory Program, handled the project on a part-time basis. Other shellfish, finfish, and coastal land use problems entered the picture.

By 1967, two full-time marine extension agents were assigned to programs in commercial fisheries development and marine science education. Funding for this program was provided by a mixture of State and Federal programs. With activation of the Sea Grant institutional program at Oregon State in 1968, the Marine Advisory Program section of the Cooperative Extension Service was established. The Marine Advisory Program was assigned responsibility for all extension activities dealing with marine resource use and public marine science education.

The Marine Advisory Program contributes to increased employment opportunities in marine-related industries, to more complete and efficient use of marine resources, and to increasing public understanding of the ocean's potential and limitations. It also helps develop the human resources of sea people, thereby contributing talent to the pool of community leadership.

The Marine Advisory Program staff is trained in disciplines which parallel teaching and research strengths in Oregon State's Sea Grant program. Specialties include marine economics, physical oceanography, seafood technology, fin and shellfisheries, business management, marine science education, and marine science information. With this team—five staff members in three coastal areas and four members on campus—OSU has both subject matter and geographic coverage of Oregon. The staff anticipates expanding into recreation, marketing, pollution, coastal land use, ocean resource law, and other marine-related disciplines.

The effective strength of the OSU Marine Advisory Program staff is considerably increased because of its affiliation with the university's Cooperative Extension Service. OSU is Oregon's Land Grant institution, with a tradition of service to the state through broadly based extension work in agriculture, home economics, youth programs, urban and rural development. When Oregon State was designated as one of the first three Sea Grant centers, it organized the Marine Advisory Program under the Cooperative Extension Service so that the advisory staff might take advantage of the resources, techniques, accumulated knowledge, and experience of the extension staff.

As Oregon's "county agents in hip boots" carry on their activities throughout the state, they work closely with county commissioners and local county extension agents to gain their understanding and cooperation as well as financial support for work in their counties. County agents are vital links when setting up local advisory committees to help identify problems peculiar to their communities. Regular extension specialists on the campus assist Marine Advisory Program staff members in approaching subjects such as marketing, living resource management, and data processing.

Operating in this way, as an integral part of the Cooperative Extension Service at OSU, the Marine Advisory Program has taken as its own the philosophy of the Oregon extension program: That extension is an organized, but informal, people-oriented education program to put useful knowledge to work. Bill Wick put it this way:

"Disseminating technical information in easy-to-use terms is a part—but only a part—of extension education. People-orientation is the key. We must work in such close partnership with sea people that *they* have the major role when it comes to identifying needs and setting priorities."

In practice, the Sea Grant Advisory-Cooperative Extension Service link works at Oregon State. As a case in point, a marine extension agent and a specialist together identified the need for encouraging commercial fishermen in Oregon to view themselves not as fishermen alone, but also as businessmen.

"Many fishermen make decisions that affect their income without really considering the business aspects of their decisions," agreed Bob Jacobson and Fred Smith, OSU extension marine economist. Smith, as a result of his work with commercial fishermen, had begun to put together the elements of a short course.

In a few months, the first of the "Professional Fishermen's Series" was presented in a coastal port. Smith and Jacobson had worked together to arrange the meeting. Jacobson contacted key fishermen, the "highliners," to get their support and participation. They were among the opinion leaders in the fishing community, Jake knew. Smith, together with Marine Advisory Program editor Dick Richardson, prepared a publication entitled, "Fishing Business Management and Economic Information," that was to serve as a text. Later, when "Professional Fishermen's Series" were conducted in inland cities for the commercial fishermen who lived there, Smith and Jacobson called on county agents for help. They responded with places to meet, local publicity, and other support. Fishermen turned out and continue to do so. Sessions have been conducted now in every major coastal port and a number of inland cities.

Another early effort was sponsorship of annual "Town Hall" meetings in the state's ports. Their purpose was to provide a forum for exchange of information between commercial fishermen and state and federal management and regulatory agencies. It was a case of everyone agreeing that such a dialog should take place, but no one doing anything about it, until the OSU Marine Advisory Program came along. Today, the meetings are well-established, and neither the agencies nor the fishermen would give them up.

Not all Sea Grant institutions are also Land Grant designates in their states. In Washington, for example, advisory activities have taken a different turn in part because Washington State University is the Land Grant school, while the University of Washington is the Sea Grant center. Marine advisory activities are coordinated at U.W. by Robert Harris and an expert in seafood processing, Bob Palmateer, works directly from the university. Another advisory service representative, Buzz Johnson, works for Clover Park Vocational-Technical Center, near Tacoma. Clover Park is a participant

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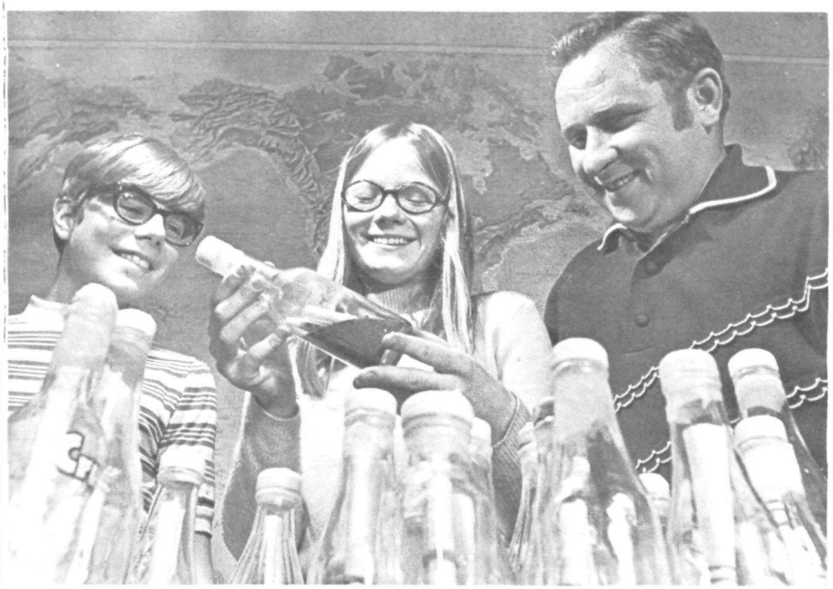
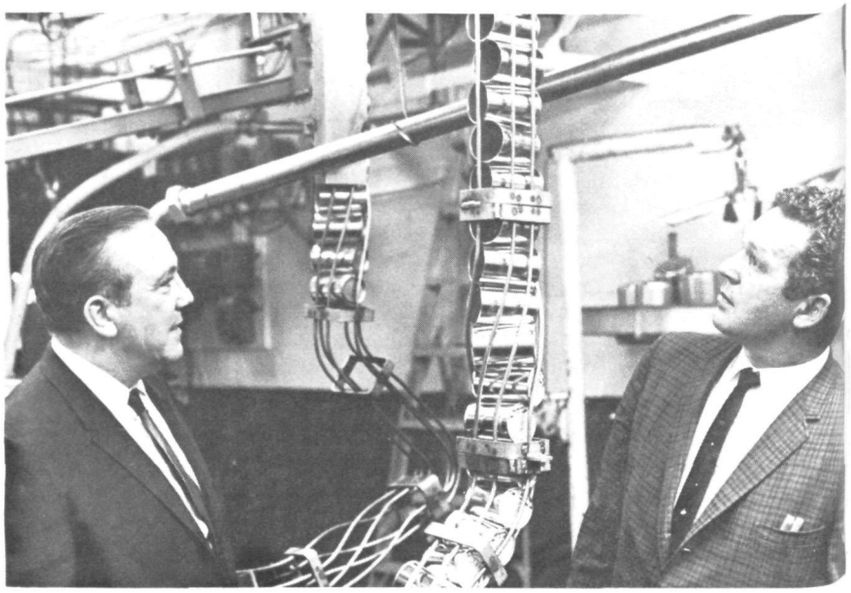




Sea Grant marine advisory programs help men with the critical problems that arise when they begin to use the sea intensively. (Top left) Members of the Oregon State University Marine Advisory Program staff learn how to mend fishing nets. (Top right) OSU extension agent observes procedures in a shrimp packing plant. (Center row, left) Don Giles, OSU marine science education specialist, conducted a demonstration project using drift bottles to help high-school students study ocean currents. (Center row, right) Robert E. Palmateer, at right, seafood specialist with the Washington Sea Grant Advisory Services, discusses canning procedures with Edward J. Gruble of Hilton Seafoods Co., Seattle. (Lower left) John Doyle, University of Alaska marine advisory representative, travels the state bringing information on technological advances to the marine community. Here, he observes how gravel-filled barrels are used as breakwaters in some parts of Alaska, a practice he is attempting to change. (Lower right) OSU marine extension agent Paul Keikkila talks with the operator of a marine ways on Oregon's south coast.

in the UW Sea Grant program. Washington, then, is organizing differently than if it were also a Land Grant school.

Despite organizational variations among Sea Grant advisory programs, there are similarities, too. Most notable, perhaps, is recognizing the need to get acquainted with those for whom the advisory effort is intended. For example, Buzz Johnson's principal clientele are commercial fishermen. He had commercial fishing experience in the halibut and salmon fisheries, so he had a basis for getting to know his clientele. It is a process that requires infinite patience, a real caring for the people involved, and the support of the program head. Johnson is regularly included, rather than excluded, when matters of concern to the traditionally tightly knit fishing community are discussed and acted on.

John Doyle—until recently the University of Alaska's only marine advisory representative—has not only the personal concern for his clientele, but also a special acquaintance with the frustrations of being regarded cautiously and with doubt. For six years, Doyle has worked with native populations: Eskimos, Aleuts, and Indians. Vast distances in Alaska separate Doyle from his clientele and his clientele from technological advances. Doyle moves in for a week or more and conducts short courses. He's experienced the real test that every extension worker faces sooner or later—wondering whether anybody will show up at the meeting you've scheduled. But now he's accepted and his intensive sessions on sanitation, processing, hydraulics, lubrication, gear, refrigeration, navigation, and safety are popular.

Where he works, there often are no motels or hotels and the climate is hostile, so John Doyle moves in with someone in the community. He recalls St. Mary's on the Yukon, where the only place to stay was with the local priest. John and the priest became so enthusiastic about the work that, together, they rebuilt most of the local cannery.

After a recent trip to Alaska to accompany Doyle on his work, Bill Wick wrote to his staff:

"John's work, after six years, is beginning to pay dividends in quality improvement and business management. I wish all of us in marine extension could see results in six years."

Texas A & M University, serving a large gulf coast clientele with a variety of needs and interests, has sought to establish its knowledge of clientele and needs of its state through a series of conferences co-sponsored by Texas Gov. Preston J. Smith. A series of six workshops brought together Texans who discussed the state's marine needs as they related to industry, education, recreation, law and administration, ports and waterways, and fisheries. As a result of its conferences, Texas A & M prepared and circulated conference reports, which themselves stimulated further discussion of needs.

Within California, where the University of California and San Diego State College, Humboldt State College, and the University of Southern California all are Sea Grant participants, approaches to the advisory task vary. At Southern California, for instance, Ron Linsky heads an advisory program that emphasizes marine policy and management as much as it does scientific and technological development.

"The manner in which resources are managed and used are at least as important as the resources themselves," Linsky says. His program is operating in the milieu of a metropolis butting up against the sea. In that context, Southern California is attempting to encourage wise use of the sea at the same time that it increases the sea's value to people. The USC advisory program has begun by sponsoring a series of conferences and publications.

Conferences have focused on coastal zone management, the research needs of California decision-makers regarding coastal zone activities, and legislative proposals on the coastal zone. USC representatives have had a major role in helping shape the state's comprehensive ocean area plan. Among the publications are several on policy and management aspects of oil pollution.

Gary Smith, who conducts the advisory programs for Humboldt State College, Eureka, California, is aiming his advisory program at commercial fishermen in the region served by the college. He says that his previous experience with California's Department of Fish and Game has helped him to sidestep a lengthy get-acquainted period with his clientele. He knew many of them before he joined Humboldt State.

As a Sea Grant institution goes about meeting anticipated needs through its marine advisory work, it may also help to meet unanticipated ones. The University of Wisconsin sponsored a two-day program last year for manufacturers in the Midwest that produce underwater mining equipment. Suddenly, the conference took on the proportions of an international event. National and international interest in underwater mining brought participants from 36 states and two foreign countries. This year's program already has drawn interest from seven foreign countries.

Advisory programs at most Sea Grant institutions are providing advice and assistance to policy makers in state government. At the University of Michigan, for example, Paul Lutzeier reports that Sea Grant participants are in frequent contact with the governor's staff, the attorney general, and environmental protection and policy agencies.

"These advisory services cover many fields, from testifying at hearings concerning shoreline erosion to offering suggestions to the legislature on legislation affecting ecology," Lutzeier said.

Sea Grant institutions are actively seeking cooperation from industry in developing marine resources. At the University of Hawaii, for example, scientists are studying the possibilities of producing brine shrimp eggs commercially. The eggs are widely used as feed for salt water aquarium fishes. Besides various State and Federal agencies, an important cooperator is Carter Pyle, of Fish Farms Hawaii, a commercial aquaculture concern, which has lent the university use of two of its large rearing ponds. In addition, Pyle volunteered his own knowledge of aquaculture and willingness to lend a hand whenever the university researchers would like.

In the Northeast, the University of Rhode Island Department of Fisheries and Marine Technology produces the URI Commercial Fisheries Newsletter among other publications. A typical issue of the newsletter included articles on freezing in seafood processing, marketing seafood, and mechanization of scallop shucking. It went on to report a fishermen's forum conducted by the university.

Rhode Island has recognized that problems of the sea are not unique to a single state, but often are shared among several states. To help share solutions, too, it established the New England Marine Resources Information Program (NEMRIP) as part of its Sea Grant effort. According to Walter Gray, who heads NEMRIP, it serves New Englanders who wish information about any marine subjects or activities. In addition to publishing a monthly newsletter, which is now in its third year, NEMRIP serves as an information clearinghouse for inquiries.

In the West, too, there is an advisory program that brings activities together across state and national boundaries. The Pacific Sea Grant Advisory Program (PASGAP) was formed last year by the universities of Hawaii, Alaska, British Columbia, Washington, California, Oregon State University, and NOAA's National Marine Fisheries Service (NMFS). The program is seeking Sea Grant support, and has already published an Emergency Services Directory for Commercial Fishermen and an inventory of marine resources publications and films. Other publications are in the planning stage. Participating institutions see regional publishing a means of saving money when they share a need for a publication and when the information in the publication applies uniformly.

If Sea Grant advisory programs are anything, they are diverse in the form that they take. Each in its own way, however, is seeking to identify the needs of the marine users, then helping to meet those needs. The task is not simple, nor is it always easy. OSU's Bill Wick described advisory efforts to the Los Angeles section of the Marine Technology Society:

"It is helping people help themselves. Although it looks simple, it may be the most difficult problem facing American technology during the decade of the seventies. Technology is stacking up much more rapidly than utilization of the information.

"The problems of technology stacking up could be solved if we only take the problem of technology transfer seriously."

Advisory programs are not going to "just happen," Wick warned. They require the partnership of industry, government, and education along with a high level of staff competence.

Sea Grant institutions today are putting those elements of effective advisory efforts together. □

Seeking better design criteria, the Environmental Data Service is learning what happens to high-rise buildings

When the Wind Blows

BY PATRICK HUGHES

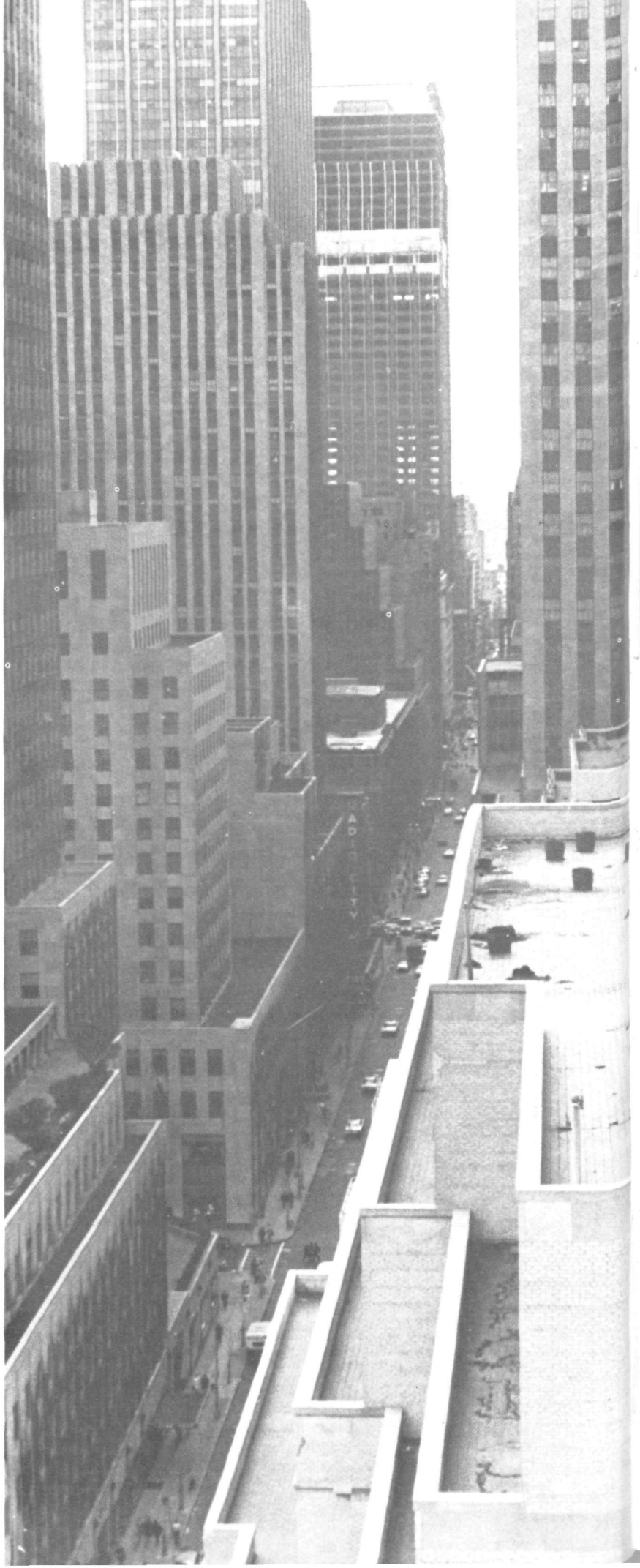
"This city is like a good many others, with nowhere to go but straight up. In the city of tomorrow the elevator will largely replace the automobile."

These are the words of Nathaniel Owings, San Francisco municipal planner and one of the architects of the soaring glass-and-steel towers that increasingly dominate our urban areas. More and more Americans are working—and living—in such high-rise buildings, structures which, because of modern design trends toward lighter, more slender buildings with larger window panels, are increasingly vulnerable to serious wind damage.

Since the skyscraper building boom of the 1930's, lighter materials and "curtain wall" construction have approximately halved the average weight of high-rise buildings. Yet, despite radical changes in the buildings themselves, there has been relatively little change in the wind-loading design criteria for their construction. This has led rather recently to scientific studies to measure accurately the effects of wind loading and stress on high-rise structures.

Herbert C. S. Thom of NOAA's Environmental Data Service, a prime mover in the statistical application and adaptation of climatological data to engineering problems, is working with Dr. Richard D. Marshall of the National Bureau of Standard's Institute for Applied Technology in a cooperative study designed to probe the nature of strong winds and to assess their aerodynamic interaction with the buildings on which they impact.

Although the building codes of most American cities make some provision for wind loading, the criteria vary from city to city, and the discrepancies become larger as the buildings increase in height. We need to know a lot more about the relationship of wind and building and to standardize our design criteria to accommodate it safely.



Chicago Tribune photo

Tall buildings often generate their own private gales, causing girls' skirts to billow in a phenomenon that has been dubbed the "Monroe effect." (Chicago Tribune photo)

One of the greatest weaknesses in today's skyscraper structures, in terms of susceptibility to wind damage, is the "cladding," the engineer's term for the building's "skin." Glass panels, because of their increasing use in modern curtain walls, must now withstand not only large wind-loading forces, but also the various wind-caused distortions of the entire structure; yet many building codes still specify wind-load criteria only for the frame, not for the design of curtain walls and glass panels.

On March 23, 1970, a symposium on "Wind Effects on High-Rise Buildings" was held at Northwestern University in Evanston, Illinois. Sponsored by the Chicago Committee on High-Rise Buildings, it was called to assess the current state-of-the-art with respect to the formulation and application of wind-load criteria, and to document the history of the study of wind effects on high-rise buildings for the architects and engineers designing today's skyscrapers.

The 984-foot Eiffel Tower, erected for the Paris Exposition of 1889, was the first skyscraper-like structure specifically designed to resist an assumed wind loading. Gustave Eiffel also had been the design engineer for the Statue of Liberty, erected between 1883 and 1886. Miss Liberty's height of 151 feet, 5 inches made her comparable in size (but not in weight) to the highest buildings of the day. The major design problem was resisting the force of the wind on the large-surfaced but hollow, copper-sheathed figure. Eiffel's solution was a diagonally braced frame inside the statute, the most comprehensive wind-bracing system used to that time for any American structure other than a bridge.

The word "skyscraper" itself was first coined in Chicago in 1889 to describe the tall buildings then being erected, although all were but 13 stories high. A few years later, the 16-story Monadnock Building was erected in the same city. It was then the world's largest office building and remains today the last great building erected in the ancient tradition of masonry architecture. Its exterior walls are six feet thick at the base, while a braced frame of cast-iron columns and wrought-iron beams supports the floors and roof.

Three years after the Monadnock Building's completion, Chicago was struck by an 87-mile-per-hour wind, the highest ever recorded in that city. Engineers found that the building moved only ¼ to ½ inch, demonstrating the stability of such a massive structure.

By 1930, however, building design concepts had changed radically. To quote contemporary engineers: "Light and air are more than ever considered of prime importance for attractive occupancy and high rentals, . . . we seem to be at the beginning of a period of super-skyscraper construction in which slender towers will rise from a much larger base of city-block dimensions."

The importance of wind loading on such towers—particularly today's glass-walled towers—demands a much more sophisticated design approach than was needed in the construction of yesterday's more massive structures.

Probably the most famous wind-caused structural failure was that of the Tacoma Narrows Bridge, designed to resist a steady wind of at least 100 miles per hour. Several months after its completion in 1940, the main span began to oscillate in a gusty 42-mile-per-hour wind; within a few hours, the aerodynamically unstable bridge literally tore itself apart.

Few, if any, tall buildings have failed catastrophically because of wind loading except during construction, when failure rates are relatively high. In the Miami hurricane of 1936, however, both the Meyer-Kiser Building and the Realty Building suffered serious structural distortion and widespread damage to their exterior cladding. Both buildings swayed violently throughout the storm. The upper portion of the south wall of the Meyer-Kiser building was displaced as much as two feet by the force of the wind, which bent and twisted 10-to-12 inch structural steel members supporting the south face.

The design of a structure to withstand the effects of wind begins with a study of the climatological data available for the proposed site. The probability of strong winds and their relative duration and direction are used to design a wind-tunnel study of building models to derive wind-loading data needed for the design of both the internal structural frame and the building's external covering. The models are mounted on a turntable to permit the study of the wind from any direction, usually the dominant or prevailing natural wind directions for the site.

The winds which form a part of a building's natural environment are strongly influenced by surrounding structures and local topography. In wind tunnel tests, therefore, local structural and topographic features are also reproduced in model form. This permits simulation of their influences on wind characteristics. At Chicago, for example, wind off Lake Michigan is much smoother and steadier and uniform with height than wind blowing over land, which is usually more turbulent and gusty and increases with height.

A great deal of detailed wind-loading design data has been derived from wind-tunnel studies. Unfortunately, a wind tunnel cannot exactly reproduce the atmospheric processes that occur in nature. In particular, the turbulence, gustiness, and variation with

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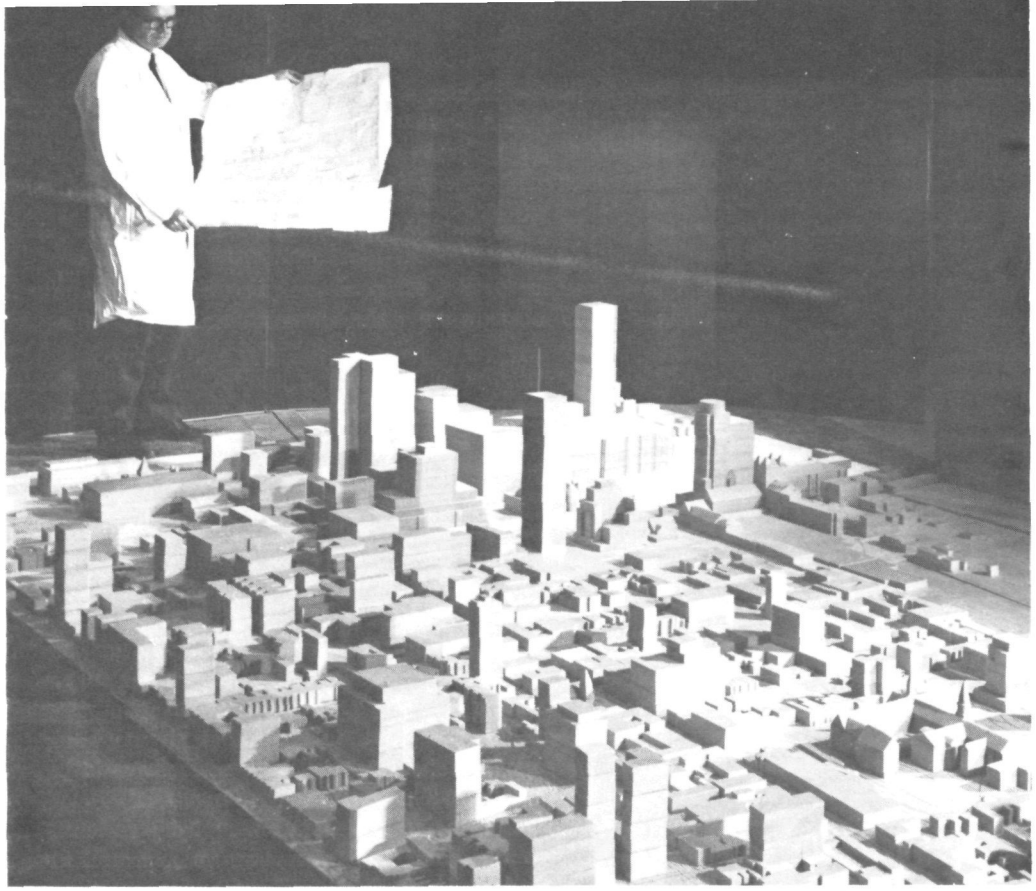


A scale model of downtown Montreal was built for wind-tunnel tests conducted to develop wind-design data for one of the tall structures in the center of the model.

height of the natural wind are difficult to simulate. The practice, therefore, is to assume that the steady or quasi-steady flow of the wind tunnel produces approximately the same effects as the variable and turbulent flow of the natural wind; this may not be a valid assumption.

Another concern is the dynamic interaction of wind and building. How important are the movements of the building itself on the natural wind flow around it? In most cases, the wind-tunnel models now being tested are rigid and do not oscillate and react as do their full-size counterparts. A realistic estimation of the effects of wind loading on buildings requires dynamic and statistical studies of full-scale structures in their natural environment.

Although only a few studies have been made of actual wind loading on full-size buildings, results indicate there is a substantial difference between the real-life situation and the wind-tunnel simulation.

The pioneer experiment in this field, a five-year study of wind loading on the Empire State Building, was completed in 1940. J. C. Rathburn, the principal investigator, reported that at times the wind blew 70 miles per hour at the top of the building, while below the 70th floor there was no wind at all. There were even cases where negative wind pressure or suction occurred on what was apparently the windward side of the building! One of Rathburn's conclusions was that "the natural wind movements are not at all like those in a wind tunnel."

No similar, full-scale studies were conducted in the succeeding 20 years, but recently several have been undertaken. In a current study involving a 15-story building in London, wind gusts have frequently been observed to rise from zero to peak velocity in less than a second, with fluctuations from positive to negative pressure occurring in the same time frame.

Full-scale experiments are both costly and time-consuming. They require a relatively large amount of research and data-processing effort in proportion to the amount of practical design data they provide. Statistical investigation of wind gust pressures on cladding, for example, involves measurement of pressures whenever high winds occur. A modest sample of 25 maximum-pressure peaks from 30-minute recorder tracings involves 90,000 readings per cladding position.

In the case of the structural frame, many wind speeds and directions must be investigated to determine the most severe wind-loading case. With several thousand members in a structural frame, the loading combinations have to be studied by computer. Several computer systems, such as STRESS, FRAN, STRUDL, and EASE are now available for the analysis of building frames. Computers, in fact, are currently used in the complete structural design of most new high-rise buildings.

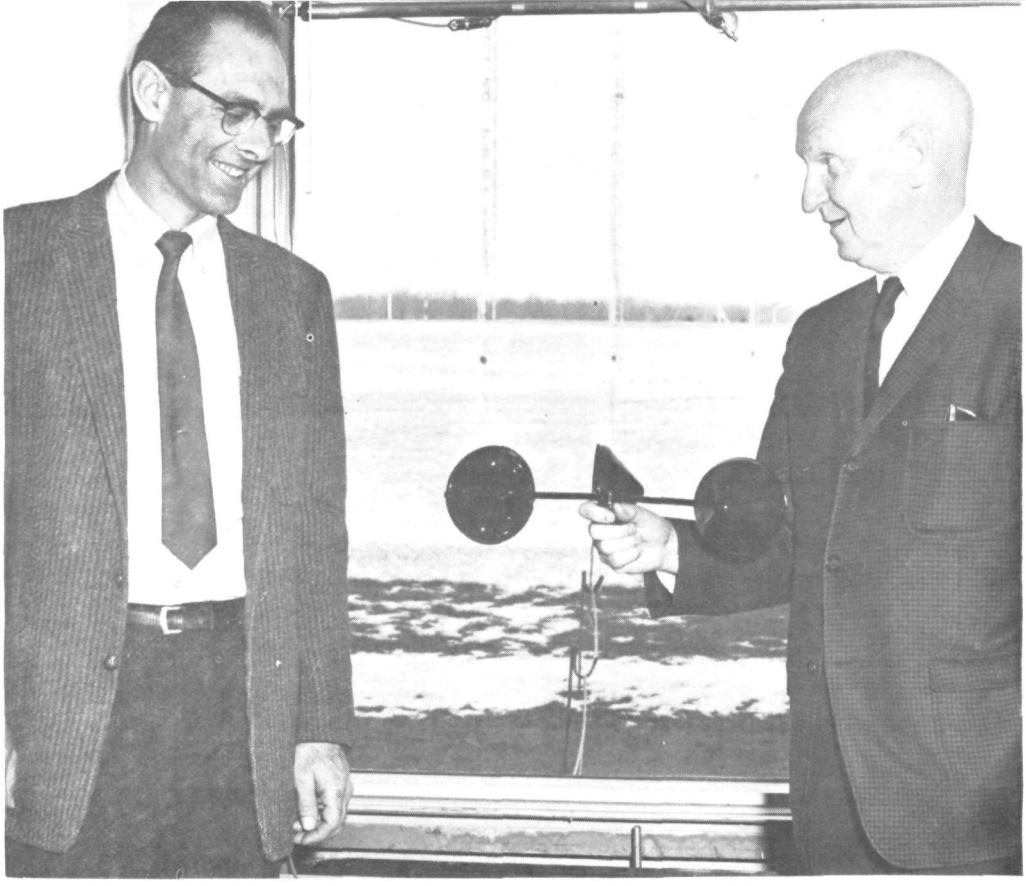
Because of the complexity and expense of full-scale studies, design engineers rely mainly on local climatological information to derive basic design wind-speed data, then on wind-tunnel tests to translate these data into equivalent loads for structural design. Full-scale studies, however, provide the only sure means of checking the validity of such wind-loading design criteria. Their essential role is to provide both guidelines and corrections for simpler, more economical wind-tunnel experiments.

In a paper given at an international research seminar on wind loading in Ottawa, Canada, in 1967, P. N. Joubert, L. K. Stevens, M. C. Good, E. R. Hoffman, and A. E. Perry of the University of Melbourne concluded that none of the previous full-scale experiments had provided generally applicable knowledge of the effects of the real wind on tall buildings, principally because of the almost total lack of measurement of the natural wind structure itself. One of the weaknesses of the Empire State Building tests, for example, was that the true incident wind velocity was not known, and therefore could not be related to the wind-generated pressure measured on the building's walls.

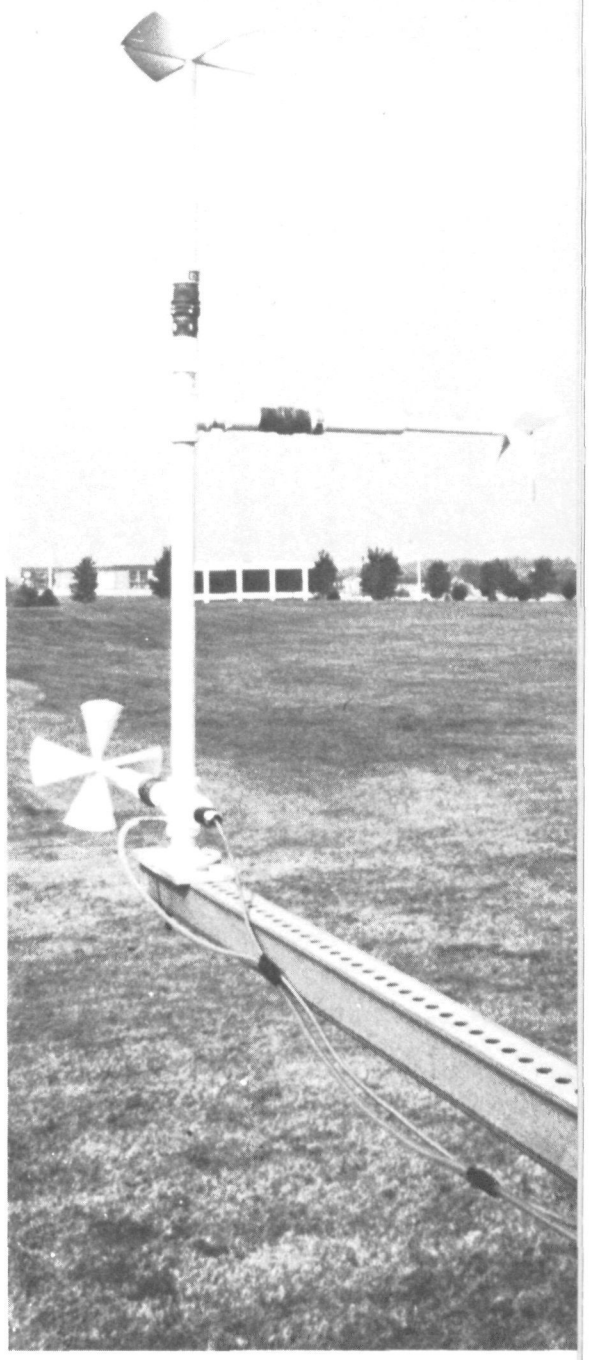
Since the natural wind structure is the only criterion by which full-scale test results can be compared, it is necessary to obtain measurements of the natural wind characteristics and effects at a variety of sites before adequate data will be available to formulate realistic wind-loading criteria. This conclusion led Joubert and his associates to undertake a controlled, full-scale study on a campus building at the University of Melbourne.

The Australians' test results showed that the pressure effects of the real wind on their full-scale building were significantly different from those obtained in simultaneous wind-tunnel tests on a model of the building. Their study demonstrated the need for additional carefully controlled, full-scale experiments and was the impetus for the current study by the National Bureau of Standards and NOAA's Environmental Data Service, undertaken in 1969.

The wind-loading criteria of most American cities' building codes are based largely on wind-tunnel tests. The primary objectives of the NBS/EDS study are to obtain the real-life data needed to formulate new



(Left) Dr. Richard Marshall of NBS and Herbert Thom of EDS (at right), are studying the effects of wind loading on structures. In the background are several of the towers set up for the experiment. (Below) One of the tower-mounted clusters of fast-response anemometers.



building-design criteria for strong wind conditions and to develop, if possible, improved modeling techniques for wind-tunnel studies.

The experiment currently involves the precise measurement of wind loading on Building 226 of the new National Bureau of Standards complex in Gaithersburg, Md., just outside Washington, D.C. The test building has a relatively clear exposure to the north and west, the prevailing directions for strong winds. Pressure sensors measure both steady and fluctuating wind-induced pressures over the walls and on the roof. Simultaneous wind observations are recorded by fast-response anemometers (wind-velocity recorders) mounted on six special towers located directly north of the building, so that the building pressure patterns and fluctuations can be related to the undisturbed incident wind structure. Although the site selection was based on the clear exposure to the north and west, winds from the south and southeast allow the study of the "shielding" effect of nearby buildings.

Two years' effort has gone into the development of the instrumentation and data-collection techniques for this study, and the system is probably the most sophisticated yet devised to measure the impact of wind on buildings.

To adequately describe the oncoming wind structure, it is necessary to document both the average wind velocity and the turbulence characteristics of the wind field. Mean velocity is obtained by positioning anemometers at various levels on the wind towers and averaging their readings. The turbulent components of velocity are also described by statistical analyses, which require simultaneous recordings for points having horizontal as well as vertical separation. This is the reason for the six meteorological towers, spaced 50 to 350 feet apart.

Wind instrumentation includes four National Weather Service anemometers mounted at the 10-meter level. These instruments are used only to correlate the observations with National Weather Service wind records. Faster-response anemometers are required to measure the wind's turbulent fluctuations. These anemometers have a fixed orientation and a three-instrument cluster is therefore required to measure the three-dimensional components of turbulence at a given point. Currently 21 fast-response anemometers are in operation.

Pressure intensities over the four walls and roof of the building are measured by 47 transducers. The ambient or natural air pressure in the undisturbed wind field is also measured on one of the instrument towers.

Because of the large quantity of data involved in full-scale studies, a computer regulates the input from all sensors, computes the velocity vector normal to the building, and digitizes the data collected for later recall or analysis. In case of a power failure, the computer will preserve all memory information and is capable of automatically restarting after power is restored.

The test building itself is only a four-story structure, and is quite stable, even in extreme winds. However, once the techniques for instrumentation, data acquisition, and data reduction have been perfected and thoroughly tested the study will shift to taller buildings, where the response of the structural frame to aerodynamic forces is of primary concern.

Since one purpose of the study is to rate the reliability of wind-tunnel derived criteria, a model of NBS building 226 and its environment is being tested in a wind tun-

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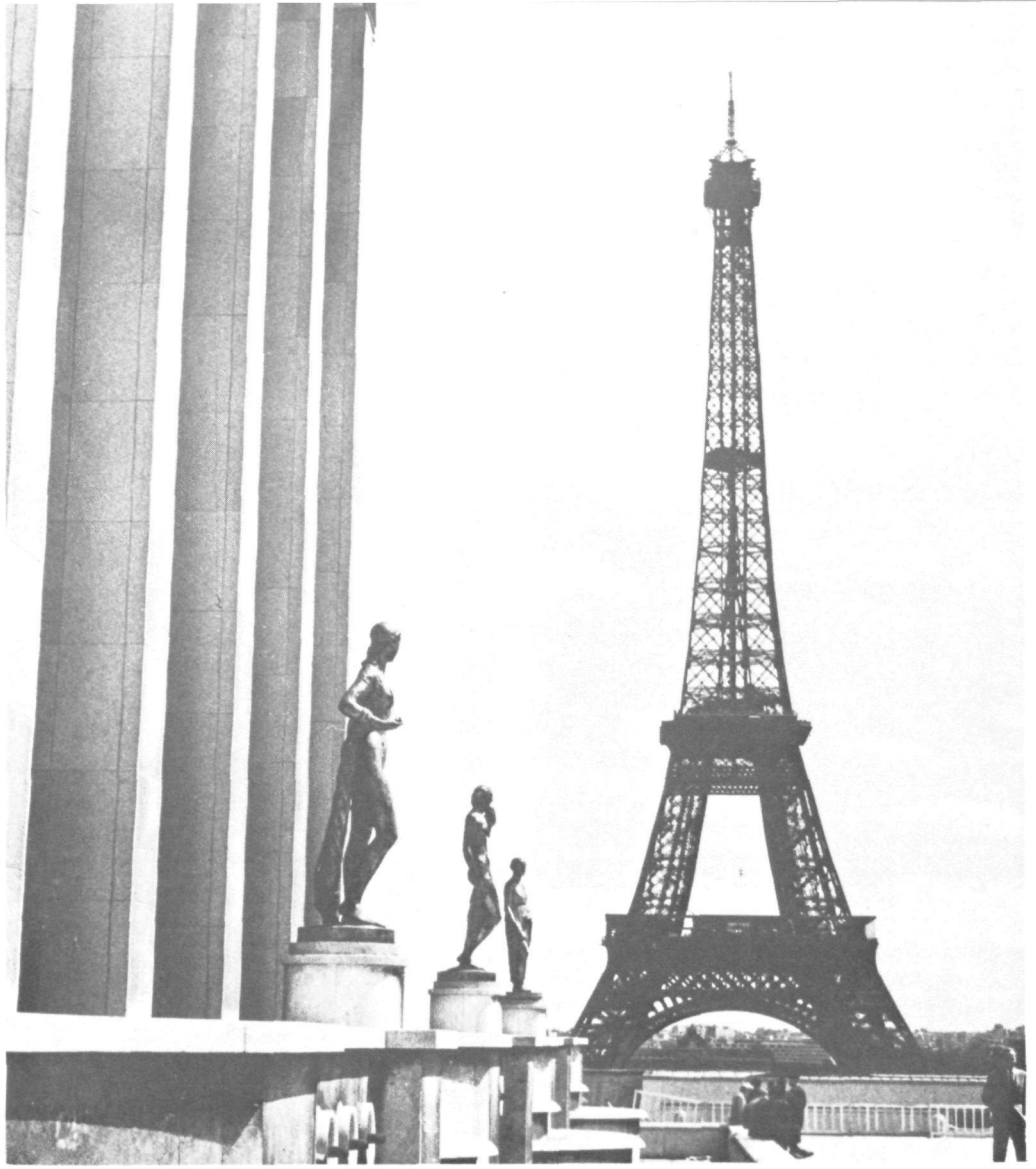


The 984-foot Eiffel Tower was the first skyscraper-like structure designed specifically to resist an assumed wind loading.

nel, with the natural winds actually recorded on the real building used as input. This companion study is being performed under contract by the Fluid Dynamics and Diffusion Laboratory of Colorado State University. The wind-loading data collected in this phase of the program will be compared with those taken from the building itself, so that a critical evaluation can be made of how well the model tests predict the effects of the natural environment. This same wind tunnel was used only recently to study wind loading on the world's tallest building—the new World Trade Center currently under construction at the foot of New York City's Manhattan Island.

This is not the National Bureau of Standards' first effort to probe the effects of wind on high-rise buildings; as far back as 1926, the world-famous aerodynamicist Hugh Dryden and his colleague George Hill of NBS conducted model experiments on the distribution of wind-loading on a tall building in a uniform and steady airstream.

In addition to the NBS study, the Environmental Data Service is also collaborating with Professor Sean Mackey, who is conducting wind-loading experiments in Hong Kong, where a special ten-story building has been erected for his use. This building's Cape Aguilar site is particularly suitable for such a study, since high winds associated with typhoons are frequent. Through an exchange of instruments arranged by Thom, NOAA anemometers have been installed at Mackey's experimental site, and anemometers from Hong Kong have been set up at the National Bureau of Standards installation at Gaithersburg, Md. This will allow correlation of the results of this study with the NBS experiment and with National Weather Service wind records.

One of the most pressing, wind-related problems facing the design engineer today is the determination of peak gust pressures and suctions for cladding design. Positive pressure usually develops on the windward side of the building, and negative pressure or suction around the corners and on the leeward faces. A number of recent wind-tunnel tests have indicated that the negative pressure over the major portion of a curtain wall may be 1.25 times the computed normal pressure. In the corner areas, it can be even higher. Wind-tunnel tests on models of the 60-story Chase Manhattan Building in New York and the 100-story John Hancock Center in Chicago, for example, indicate that the negative pressure around the corners of a building can be twice as high as the normal pressure, depending on the shape and exposure of the building.

In the contemporary high-rise building, the air conditioning and vertical air circulation phenomenon known as the "stack effect" can develop internal pressures as high as those produced externally by moderately strong winds. In the design of curtain walls, therefore, this internal pressure must be added to the external suction caused by the wind. Recent losses of window panels from several tall buildings indicate the reality of the problem.

The complicated interaction wind wakes from surrounding buildings also raises difficult questions. To what extent, for example, should the design engineer be expected to anticipate future changes in the wind environment that might be caused by the erection of new buildings?

Another serious wind problem only too familiar to city dwellers is the strong wind frequently encountered around the base of a tall building. This can cause discomfort and sometimes disaster to pedestrians, and often creates a miserable environment for the trees and plants so common to the plaza areas of many new buildings.

One of the few pleasant (at least for males) aspects of this phenomenon is the effect of such winds on girls' skirts, which has led Richard Parmelee, Associate Professor of Civil Engineering at Northwestern University, to dub it the "Monroe effect," in honor of the famous billowing of Marilyn Monroe's skirt in the movie, "The Seven-Year Itch."

This situation, in which a tall building generates its own private gales, is common to scores of buildings throughout the country. The basic cause is building downflow; winds are usually stronger at the top than at the base, creating a pressure pattern that generates winds blowing down the face and away from the building at street level.

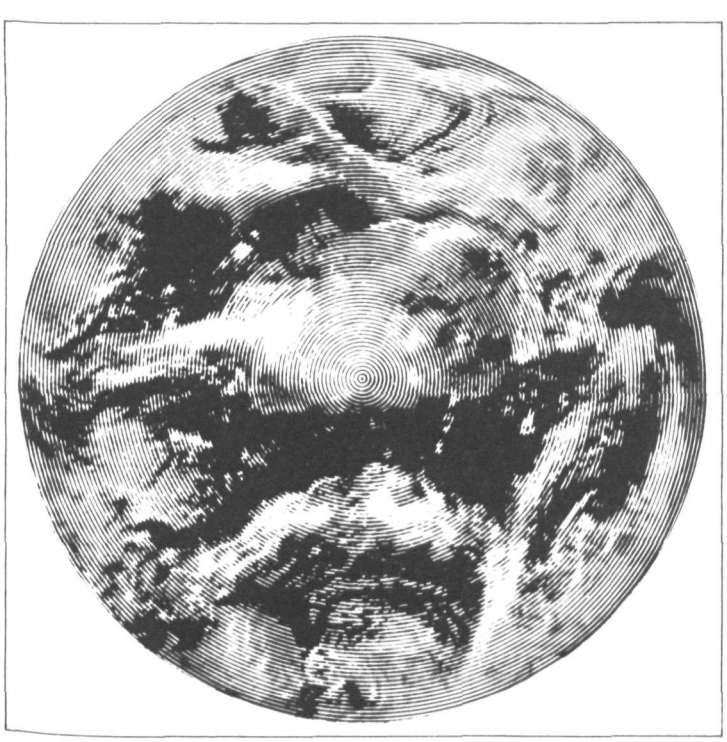
In cold weather, these winds become almost unbearable for pedestrians, who must stagger past at implausible angles, cut to the bone by icy blasts. In summertime, it means that plaza fountains soak passers-by, rather than recirculate their water, as their designers intended.

And that's in good weather. Earlier this year, a blizzard sent gales whistling around a Cleveland tower, knocking over a trailer truck, pushing a parked Volkswagen out into traffic, and literally tearing the door off of another car. Construction workers had to form human chains to help people in and out of the building.

This usually doesn't happen where tall buildings are clustered together—as in New York City. It is the isolated skyscraper that generates gale-like winds at its base. Architects and engineers weren't aware of the serious dimensions of the problem until this last decade, when high-rise buildings began sprouting up in suburban areas. Fortunately for girl-watchers, at least, there is as yet no known cure for the "Monroe effect." □

Created to protect man from his environment, the World Weather Program also seeks to help save the environment from man.

OUR GLOBAL AIR



"Through the World Weather Program, the nations of the world are combining their efforts to gain new knowledge of the global atmosphere, provide better weather forecasts and warnings to all countries, and assess the damage man has inflicted upon the earth's atmosphere."

PRESIDENT RICHARD M. NIXON

An international experiment is scheduled to be mounted in the Atlantic during the summer of 1974, to study the behavior of cloud clusters and their role in the larger circulation of the atmosphere.

Called GATE—for GARP Atlantic Tropical Experiment—the planned project is part of the Global Atmospheric Research Program of the World Meteorological Organization and the International Council of Scientific Unions.

The Global Atmospheric Research Program, the World Weather Watch, and a Systems Design and Development Program together comprise the World Weather Program. Coordination of United States participation in the World Weather Program is assigned to the National Oceanic and Atmospheric Administration.

Reporting to Congress recently on the progress of the World Weather Program, President Nixon said:

"I am pleased to report that the Program is making significant progress which will enhance the comfort, health, safety, and economic well-being of men everywhere:

—Satellite technology is being used with increasing effectiveness to gather global information for earlier, more accurate predictions and warnings of hazardous weather.

—New stations are being established for long-term measurement of atmospheric change.

—Computers have been programmed to determine the effect of pollution upon the atmosphere.

—A major international experiment in the Atlantic Ocean is being prepared under the Global Atmospheric Research Program. During the past year many nations, including the United States, have indicated their support of this tropical experiment and have made tentative commitments to provide ships, aircraft, satellites, and other observing facilities. Linked with an increased computer capability to assess and integrate results, this experiment should be an important step toward attaining a true understanding of the global atmosphere.

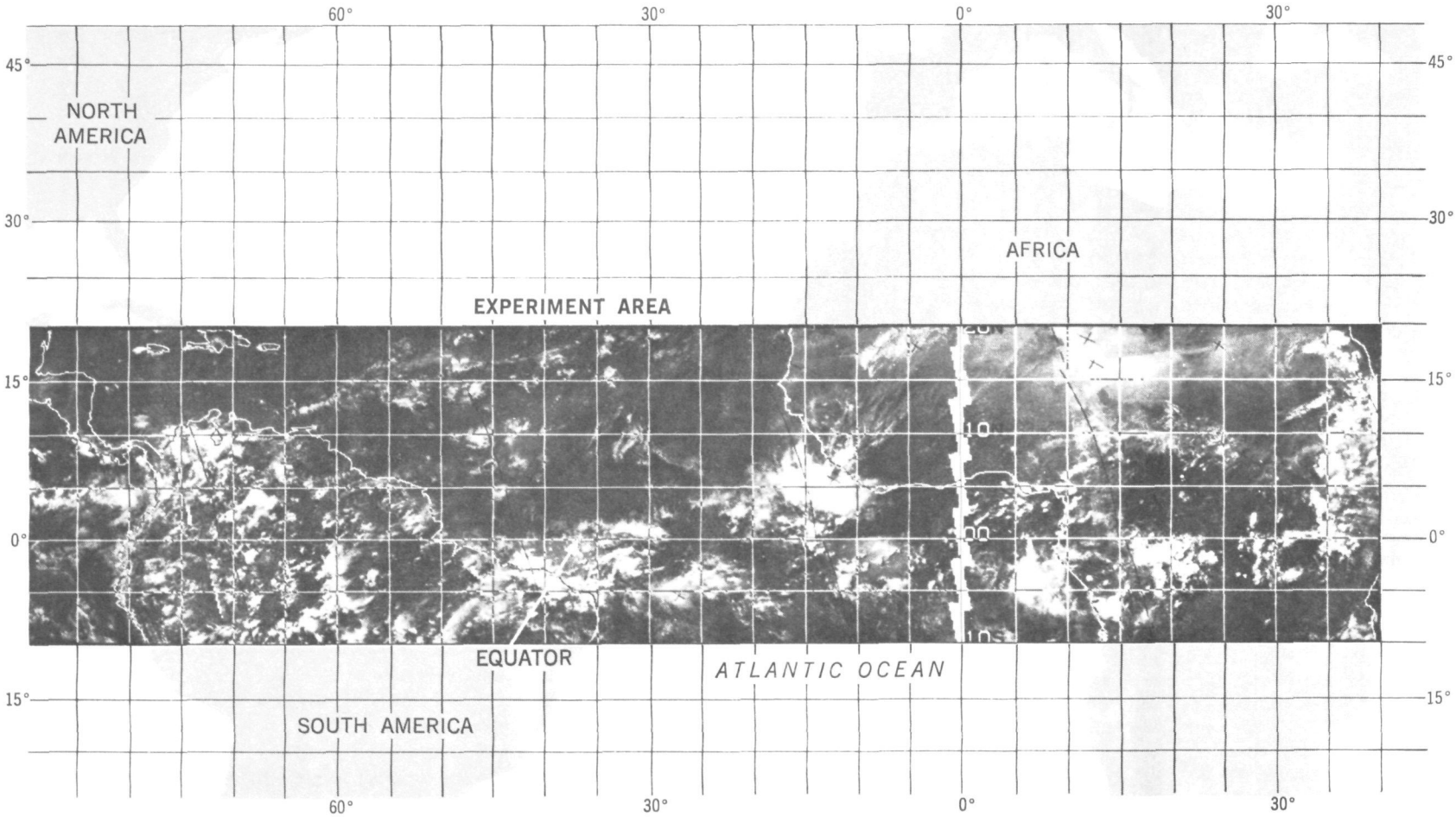
"The scientific understanding which will be developed by the World Weather Program is critical to the solution of environmental problems which are of immense concern to all nations."

"TO GAIN NEW KNOWLEDGE OF THE GLOBAL ATMOSPHERE"

The GARP Atlantic Tropical Experiment follows Bomex (Barbados Oceanographic and Meteorological Experiment) in a succession of experiments designed to gain increased understanding of the atmosphere in order to develop numerical models and program computers for long-range weather prediction.

The Bomex project, conducted in the Atlantic east of Barbados in 1969, examined the small-scale exchange of energy between sea and air; GATE will seek to learn how massive cloud clusters in the tropics transform and redistribute energy, which then is transported from equatorial to middle and high latitudes. The experimental area will extend approximately from the west coast of Latin America eastward to Ethiopia, between latitudes 10 degrees South and 20 degrees North, with a more intensive study of cloud clusters being conducted in a smaller ocean area.

After GATE, an international global observing experiment—another project of the Global Atmospheric Research Program—is tentatively scheduled for 1976 or 1977. It will rely on World Weather Watch conventional and satellite observing systems existing at the time, with additional observations as required to accomplish the experiment's objective. Planning responsibility for the First



The area of the international experiment in 1974 will extend from the west coast of Latin America eastward to Ethiopia.

GARP Global Experiment in the United States has been assigned to the National Aeronautics and Space Administration. The goal is to provide the necessary data for developing, testing, and improving the mathematical models that are the fundamental tools for understanding and predicting the long-term behavior of the atmosphere.

Mathematical modeling is a major aspect of the global research program and includes observing systems simulation studies which, in the United States, will be coordinated by the National Science Foundation. These studies will use computer techniques and available models to test the value to weather forecasting of various possible combinations of global observations. What needs to be measured, how accurately, at what intervals of space and time, are questions the simulation studies will seek to answer. Besides the National Science Foundation, both NASA and NOAA are conducting investigations of this kind.

TO "PROVIDE BETTER WEATHER FORECASTS AND WARNINGS"

Through the Global Atmospheric Research Program, new understanding of the atmosphere gained in international experiments will be used to create more accurate mathematical models for long-range weather prediction. Thus, the research program is designed to help achieve the aim of the World Weather Watch: to improve the weather services of all nations by increasing the accuracy and extending the time range and scope of weather predictions.

Impetus for the World Weather Watch came when President John F. Kennedy expressed the desire of the United States to cooperate with other nations in using space technology for peaceful purposes. Speaking to the United Nations in 1961, he said the United States "would propose cooperative efforts between all nations in weather prediction and eventually in weather control."

Later in 1961, the United Nations General Assembly approved a resolution supporting international cooperation in the peaceful uses of outer space. In the field of meteorology, the resolution proposed that the World Meteorological Organization develop a global weather network to receive, process, and transmit information from weather satellites and from earth-based instruments.

The World Meteorological Organization responded by recommending the creation of a World Weather Watch, combining weather satellite information with an expanded network of conventional observations, to bring better weather services to all nations.

In its early stages, the World Weather Watch aimed for a global conventional and weather satellite observing system, world and regional data-processing centers, and a worldwide communications network.

The global operational satellite system was realized with the beginning of the United States' Improved TIROS Operational Satellite system, which views the weather night and day over the entire earth.

World Meteorological Centers have been established at Melbourne, Australia; Moscow, U.S.S.R.; and Washington, D.C., to provide weather analyses and forecasts on a global scale.

Of 23 recommended Regional Meteorological Centers, 20 now are in operation. One of these is the Regional Meteorological Center operated by NOAA at Miami, which serves 18 nations.

Global, regional, and national centers are linked today by the World Weather Watch Global Telecommunications System.

The World Weather Watch plan for the years 1972 through 1975 calls for two or three polar-orbiting spacecraft and four geostationary satellites as an essential part of the global observing system. These spacecraft would not only make observations, but would also collect and exchange weather data. By the mid-1970's it is anticipated that the United States will have launched two oper-

ational environmental satellites into earth-synchronous orbits, and that Japan and France each will have launched one. These would supplement the spacecraft in the polar-orbiting NOAA series of the United States and the Meteor series of the Soviet Union.

TO "ASSESS THE DAMAGE MAN HAS INFLICTED UPON THE EARTH'S ATMOSPHERE"

A major new emphasis in the World Weather Watch is monitoring of atmospheric pollution by networks of baseline and regional stations.

Baseline stations in the World Weather Watch will monitor long-term changes in the atmosphere at locations with minimum influence from local or regional factors.

A satisfactory program for measuring the long-term burden of atmospheric trace contaminants does not now exist, either to monitor global trends in the atmosphere or to determine the climatic effects of these trends. In the monitoring field, only one station—operated by NOAA at Mauna Loa, Hawaii—has been measuring carbon dioxide in clean air. The 12-year record at Mauna Loa reveals that the fraction of manmade carbon dioxide remaining in the air—rather than entering the oceans and biosphere—seems to vary over wide ranges, from below 40 percent to over 60 percent. In recent years, the annual growth rate of carbon dioxide at Mauna Loa has been perhaps three times greater than during the mid-1960's. It is vital to know whether or not the Mauna Loa growth rate is typical of the globe as a whole. For this reason, the World Meteorological Organization has recommended the establishment of additional baseline stations.

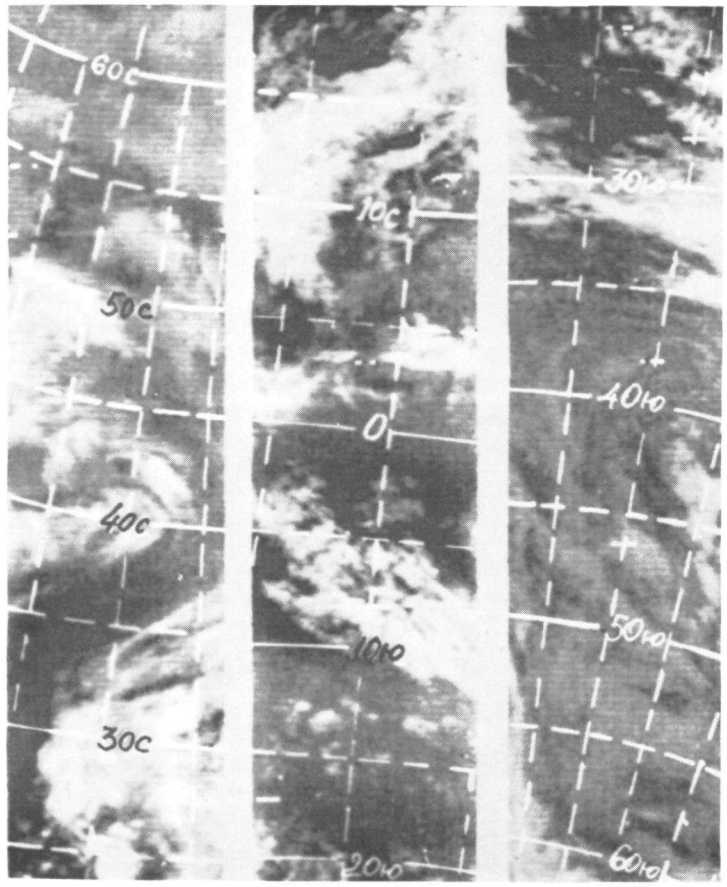
To determine the long-term effects of atmospheric contaminants on the climate, NOAA plans to establish several stations such as the one at Mauna Loa at sites in "very clean air" without nearby agricultural or pollution sources. Initially, primary measurements at baseline stations will consist of continuous ground-level measurements of carbon dioxide, the chemistry of precipitation, solar radiation attenuation, ground-level dust loadings, and vertical distribution of particles in the atmosphere.

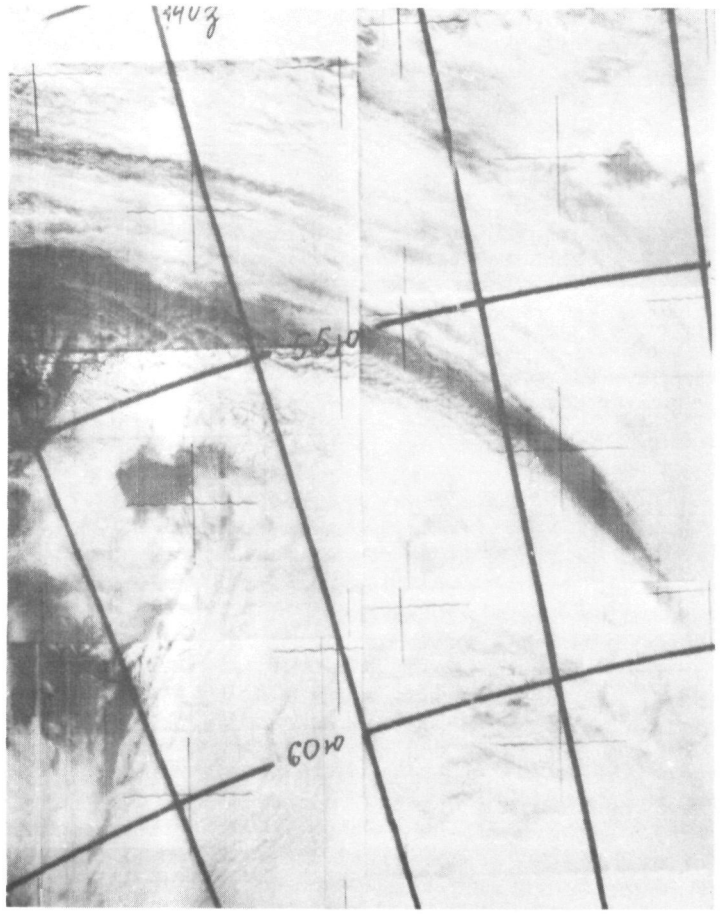
With data gathered at baseline stations, NOAA will seek to learn for example, whether carbon dioxide in the air is increasing sufficiently to produce a "greenhouse effect" upon the planet and cause a warming of the earth, or whether particulate pollution could cool the atmosphere.

The World Meteorological Organization also has recommended that each of its 135 member nations undertake to relate regional changes in air quality to changing land use practices. For this project, the Organization has defined a region as approximately 193,000 square miles—about twice the size of Oregon. Generally speaking, the regional monitoring stations should be in rural areas, so that measurements are not unduly influenced by urban fluctuations in pollution concentration.

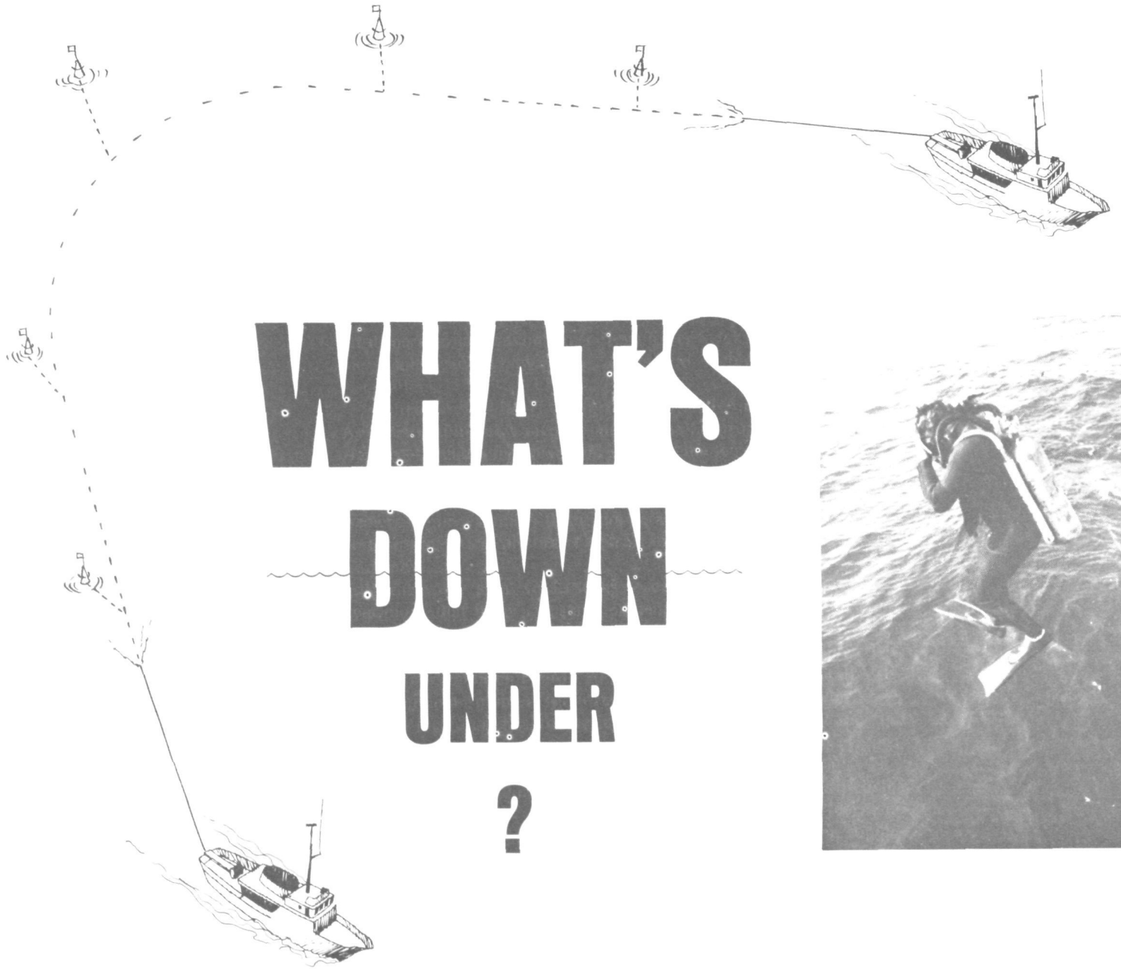
Such regional air pollution monitoring stations are being established at ten cities in the United States. NOAA's National Weather Service and the Environmental Protection Agency's Air Pollution Control Office are cooperating in the program to measure and analyze particles in the air and atmospheric impurities in rain or snow. Weather Service stations participating in the program are in or near Caribou, Me.; Atlantic City, N.J.; Raleigh, N.C.; Salem, Ill.; Meridian, Miss.; Huron, S.Dak.; Alamosa, Colo.; Victoria, Tex.; Pendleton, Oreg.; and Bishop, Calif. Analysis and publication of data from the network will be handled by the National Climatic Center in Asheville.

As Dr. Richard Hallgren, NOAA Assistant Administrator for Environmental Systems, points out: "The need for protecting man from his environment through better warning, prediction, and eventual control was the main motivation for creating the World Weather Watch in the 1960's. In contrast, the main motivation of the 1970's is to stop the deterioration of the environment and improve its quality—to protect the environment from man." □

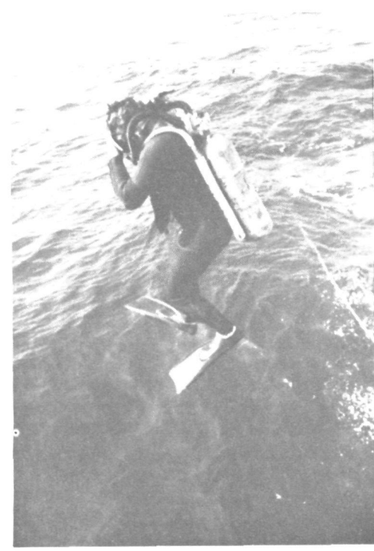




Like the United States' NOAA series, the Soviet Union's Meteor spacecraft are polar-orbiting satellites. (Top) Nighttime infrared strips and (bottom) a mosaic of daytime television photographs were taken by Meteor 8, from about 400 miles above the earth.



WHAT'S DOWN UNDER ?



When the RUDE and HECK located the wreck of a 19th-century vessel in Delaware Bay, scuba divers brought up samples of the ship's cargo of British-made chinaware. (Right) The author examines the anchor found with the wreck.

Two NOAA ships scour U.S. waters for hidden hazards to navigation.

BY RAYMOND WILCOVE

The world's most unusual "wrecking crew"—20 men and two ships—combs the ocean's depths for the skeletons of vanished ships.

Unlike other wreckers, their task is to search out and record the sites of the sea-covered wrecks of once-proud ships which succumbed to nature's fury, enemy action, or accidents. Many are hazards to shipping.

To ensure that one sea casualty does not beget another, NOAA's National Ocean Survey is constantly on the prowl for dangerous wrecks, as well as other navigational hazards, including pinnacle rocks, which rise like church spires from the bottom of the sea and can tear out the bottom of an unwary ship, abandoned oil derricks and platforms, and other submerged objects. A recent search turned up such dissimilar objects as the wreck of a twin-engine plane, clumps of concrete and aluminum, a steel ladder, railroad rails and anchors from ships which have long since rotted away and disappeared.

The ships that carry out this sometimes romantic but more often tedious work are the RUDE and the HECK, the only vessels of their kind in the United States, designed especially for this one purpose. Their commanding officer has the unusual distinction of being skipper of two ships. Each of the 90-foot, 220-ton sister ships carries a complement of two officers and eight crew.

The main equipment of the two vessels is a quarter-inch stainless steel wire called the ground wire. Suspended from surface buoys to predetermined depths, it is pulled between the two vessels as they slowly ply the water a half-mile to two miles apart. As long as the buoys form a familiar arc in the water, the coast is clear. But when they make a "V" the crew knows that the wire has found its mark. The men then measure the water over the highest point. If necessary, a scuba diver will examine the wreckage. Those so near the surface that they represent a hazard to shipping are marked with navigational aids by the Coast Guard and listed on the government's nautical charts which are prepared and published by the National Ocean Survey.

Theirs is a never-ending task, for new hazards to navigation are always being reported. Wrecked ships alone offer an almost limitless list of sunken objects requiring search and examination. More than 1400 wrecks of passenger ships, cargo carriers, tankers, freighters, warships, submarines, and other vessels dot the mud and sand-laden sea bottoms off the nation's three coasts. The largest graveyard of sunken ships is along the Atlantic coast where the National Ocean Survey and its predecessor, the Coast and Geodetic Survey, have pinpointed around 700.

Interest in wrecked ships is constantly growing with the increase in skin diving. Some sunken ships reportedly carried valuable cargoes. Some have been located and their treasures recovered. Among the better known which still keep their secrets from treasure hunters are the HMS HUSSAR and the HMS DE BRAAK. The HUSSAR is a British frigate which sank in New York Harbor in September 1780, with a reputed cargo of four million dollars in gold for paying English soldiers fighting in the American Revolution. The ship is at the bottom of Hell Gate, where three rivers meet, and the turbulent waters have defied all efforts to retrieve the treasure. The DE BRAAK, another British ship, also sank during the American Revolution near Lewes, Delaware, and the gold she carried for His Majesty's forces has never been recovered.

Lying along the Atlantic coast are the sunken hulls of 15 identified World War II German submarines. Their whereabouts are

continued

(Left) Shipboard processing of the wire-drag data. (Below left) Repairing a wire-drag buoy. (Below) Taking a bearing. (Right) The RUDE. (Top right) Bringing aboard chinaware in a net. (Right, below) Cdr. Merritt Walter, CO of the RUDE and HECK, wearing a wetsuit, examines samples of the ships' find. Uncharted wrecks and other hidden hazards pose serious hazards to navigation.

a matter of conjecture. Reports of a sunken German U-boat off Charleston Harbor, South Carolina, have been current in that area for years, but an intensive search of the reported site by National Ocean Survey wire drag ships has failed to locate it.

So far the RUDE and the HECK have not discovered any gold-laden wrecks, but have come across some interesting relics of the past. Last year they turned up the wrecks of five better-than-100-year-old ships off Charleston Harbor. The South Carolina State Archaeologist identified them as Confederate vessels, apparently sunk by Union forces as they sought to slip into the blockaded harbor.

Earlier this year, the RUDE and HECK located the wreck of an armed sailing vessel, possibly a Union Civil War revenue cutter or a Confederate blockade runner, near the entrance to Chesapeake Bay off Norfolk, Virginia. The 19th-century vessel was equipped with several six-foot cannon of 3½-inch bore, one of which, weighing about 500 pounds, was brought to the surface and placed in the museum at the National Ocean Survey's Atlantic Marine Center in Norfolk, the ship's home base.

Last year, the RUDE and the HECK found the unmarked wreck of another 19th-century vessel, possibly a British cargo vessel, in Delaware Bay between Lewes, Delaware, and Cape May, New Jersey. The wreck was laid open on the bottom with part of its cargo, consisting of thousands of pieces of neatly packed British-made chinaware, exposed. Samples of these also ended up in the Norfolk museum.

But, alluring as the prospect of finding sunken treasure may be, the task of the RUDE and the HECK is much more prosaic—and important. Hazards below the surface which pose a danger to shipping can sink the proudest and most powerful ships afloat, and the main task of the two ships is to locate them, determine if they are hazardous to navigation and, if they are, make this information known to shipping.

Prior to the development of the wire drag more than a half century ago, the universal method for making hydrographic surveys was the use of a lead line from a moving vessel. This procedure often failed to uncover such underwater obstructions as pinnacle rocks, boulders, sharp ledges, coral formations, and wrecks.

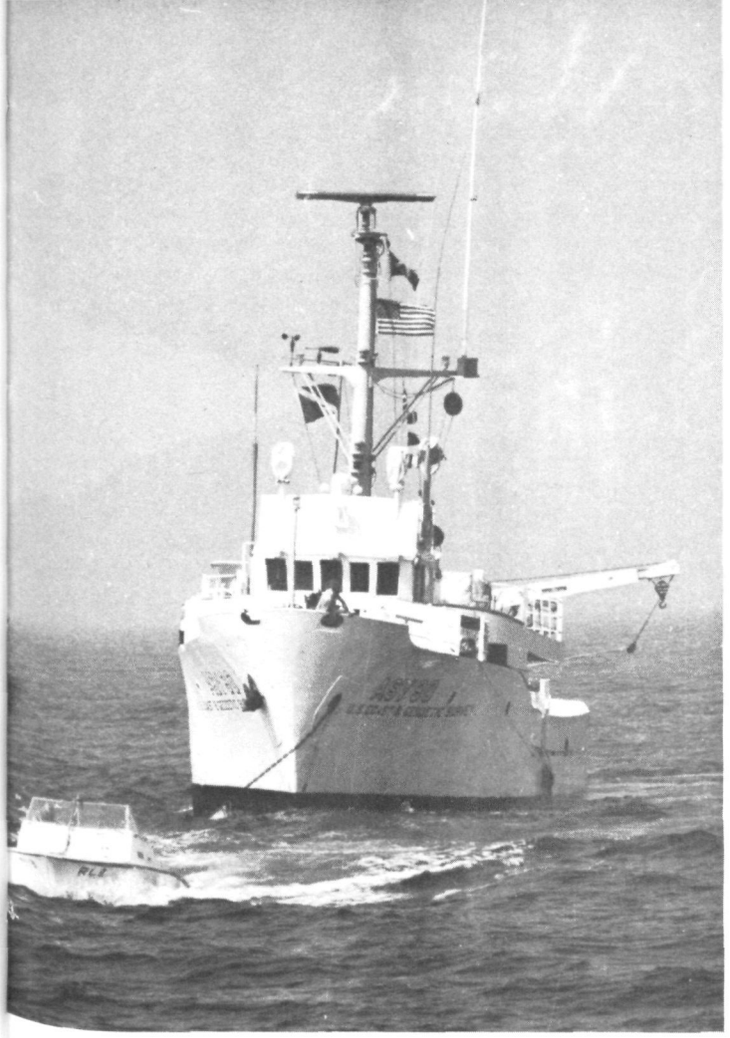
Examples of this failure were legion. In 1909, a 23-foot pinnacle rock was found in the main channel south of Vinal Haven off Maine, where the general depth was about 21 fathoms. As the rock was being surveyed, the battleship DELAWARE passed close by, unaware of the danger lurking below.

On another occasion, a 14-foot shoal was found directly in the course of steamers plying between Bangor, Maine, and Boston. At Key West, Florida, an important naval base during the Spanish-American War, wire dragging disclosed four 17- to 24-foot shoals in the principal channel, which was supposed to have an effective depth of 30 feet. In a 65-square-mile area adjacent to Key West, over 500 coral heads and shoals were found.

A 600-foot pinnacle rock was discovered off the southeast Alaskan coast in 1914 by wire drag. This shipping hazard rose to within 13 feet of the surface. It has since been named the Washington Monument Rock.

In 1916, the Battleship VERMONT, scheduled to pay a visit to Salem, Massachusetts, asked the Coast and Geodetic Survey to wire drag the approaches to the harbor to ensure there were no hidden dangers lurking below the surface. The wire drag found rocks covered by only 17 to 20 feet of water and, in the main channel, a rock which rose to within 24 feet of the surface. Each posed a definite danger to the giant ship.

The value of the wire drag was made clear again in 1961, when shoals were found eight miles southeast of Barren Islands in Alaska in only 15 feet of water. A much earlier survey, in which lead lines were used, had placed the depth in the area at 60 feet. The shoals are in the ship-



ping lane used by oil tankers enroute to Cook Inlet.

Although the lead line was universally used prior to the development of the wire drag, there were some who improvised improvements. In 1887, almost a quarter century before the wire drag became the accepted method in the Atlantic for detecting underwater obstructions, a Coast and Geodetic Survey vessel employed a variation of this technique in making a hydrographic survey off Martha's Vineyard, Mass. A hemp rope, which does not sink or rise, was used to detect Allegheny Rock off the northern point of the island. The rock rises to within six feet of the surface in 15 feet of water.

N. H. Heck and J. B. Hawley were two Coast and Geodetic Surveymen who played a key role in the development of the wire drag. In their book, "Wire Drag Work on the Atlantic Coast," published in 1915, they gave this analogy in explaining the difficulty of detecting underwater hazards with the use of a lead line from a moving vessel:

Imagine, they wrote, a balloon drifting slowly over a town. "The difficulty of dropping a weighted line so as to hit any particular small building, stack, or telegraph pole is obvious," they pointed out, even though these are clearly visible. The hydrographer, on the other hand, cannot see his targets.

Wire dragging was used on the Great Lakes by U.S. Army Engineers and in other survey operations elsewhere. It remained, however, for the Coast and Geodetic Survey to adapt the method for ocean work to the point that today, even with the development of sonar, it provides the only effective way in which all obstructions in an area can be located.

By 1910, the wire drag had been sufficiently developed so that it became the principal method employed on the Atlantic coast for locating underwater obstructions. In 1914, the method was introduced in Alaska, where surveys of the rocky coasts had been conducted by the Coast and Geodetic Survey since 1881. Since then, the wire drag has been successfully used in the coastal waters of the Gulf of Mexico, the Pacific coast, the Philippine Islands, the West Indies, and the approaches to the Panama Canal. Water areas have been dragged to depths as shallow as six feet for seaplane landing areas and as great as 350 feet for submarine trial courses.

At first the work was carried out with launches, but later larger ships also engaged in the work. They included the Coast and Geodetic Survey Ships ROOSEVELT, EQUATOR, GUIDE, OGDEN, RODGERS, MITCHELL, MARINDAN, and FARIS. Larger ships were used by the Coast Survey after World War II to locate wartime wrecks off the east coast. There were the C&GS Ships STIRNI, PARKER, and BOWEN, wartime wooden-hulled 110-foot Navy subchasers, which operated as much as 100 miles offshore until the early 1950's.

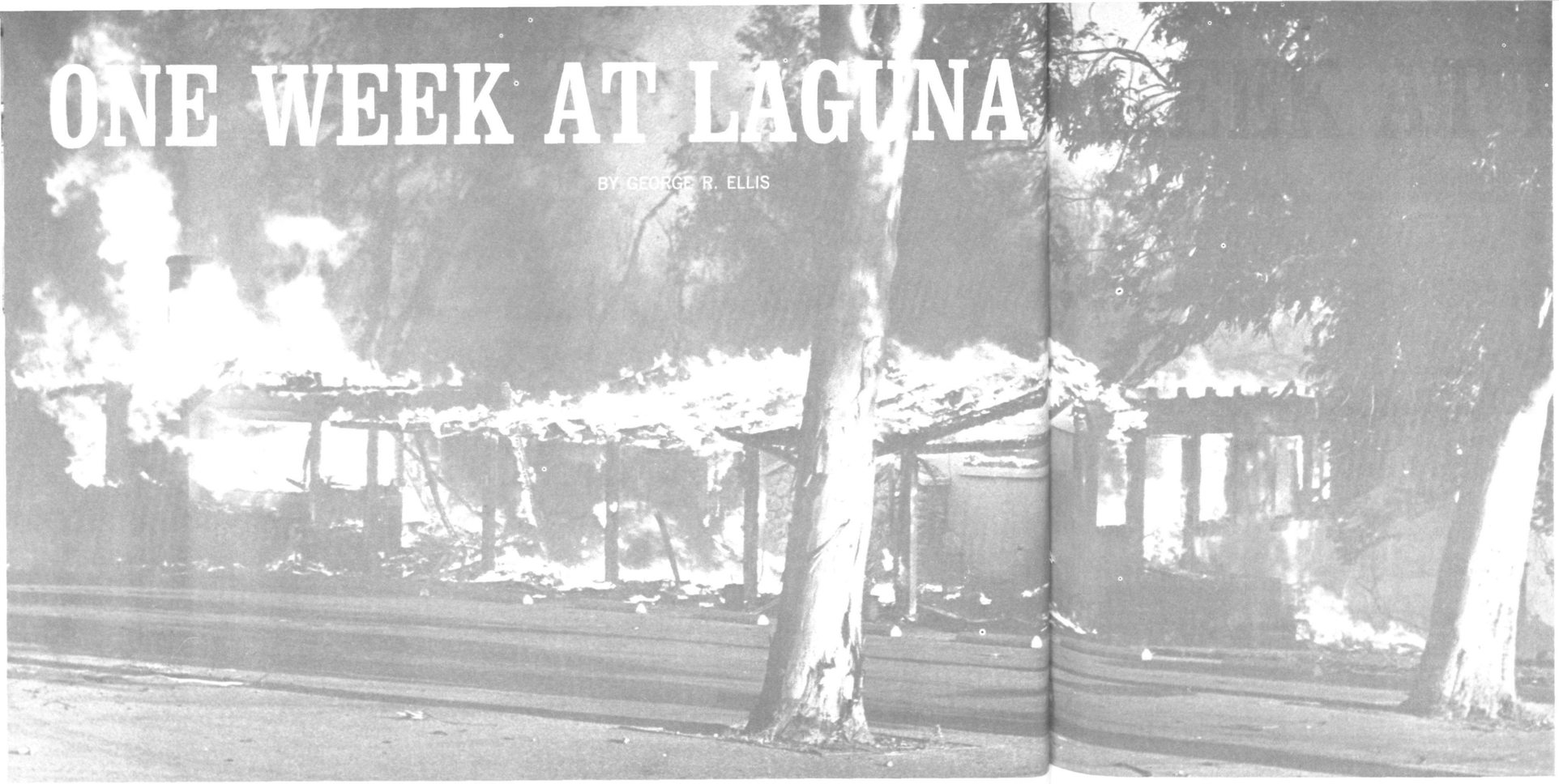
These ships were all adapted for wire dragging. The first to be built specifically for that purpose were the USC&GS Ships HILGARD and WAINWRIGHT. During the 24 years they were in service, they became a familiar sight to thousands, poking their prows into practically every inlet, bay, river, and estuary along the Atlantic coast, from Maine to Florida, and a good part of the gulf coast as well. Their last big task, shortly before they were decommissioned in 1966, was the finding of the wreck of the SS ROMANCE, an excursion liner carring 153 passengers and 59 crew which sank in Boston Harbor in 1936.

The HILGARD and the WAINWRIGHT were built in 1942 at a cost of $88,600 and $86,500, respectively. Their successors, the RUDE and the HECK, cost $872,000 each.

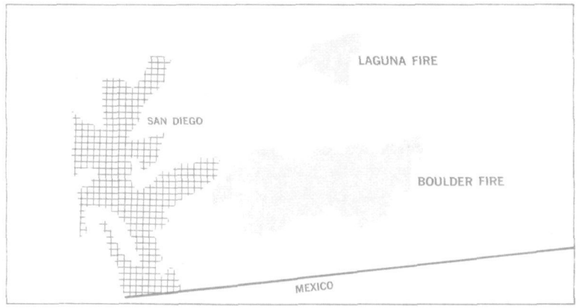
Although the RUDE and the HECK will continue to work off the Atlantic coast, more and more of their time will be devoted in the future to the gulf coast, where they did some preliminary wire dragging last year off Texas. □

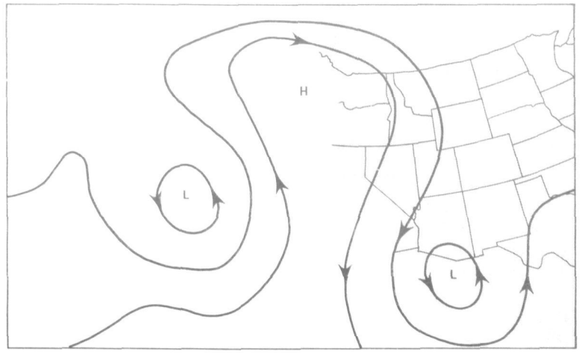
ONE WEEK AT LAGUNA

BY GEORGE R. ELLIS



Hundreds of homes were destroyed by the California forest fires of late September and early October 1970. Photographs by the San Bernardino Sun-Telegram.





(Top) The Laguna fire, second largest in recorded California history, consumed 185,000 acres. (Bottom) A classic Omega block—the "low" over the Arizona-Mexico border balanced by another over the Pacific, with a "high" between the two—brought gale force winds that drove the fire toward San Diego.

A fire-weather forecaster recalls his experiences during the battle against a 185,000-acre blaze.

This year, if nature follows the script, forest fires will ravage about two million acres in the United States.

Two million acres, three times the land area of the state of Rhode Island, scorched and useless. The damage cannot be calculated in dollars. Who can assess the worth of a park, or put a price on the animals that once inhabited these wasted acres?

And the damage goes on despite the estimated yearly expenditure of $200 million dollars to prevent fires and to fight them.

The National Weather Service has 40 field offices established to aid fire-control and forestry interests in the war against the ancient enemy . . . fire. When hundreds and thousands of men are mobilized to control a raging forest fire, it is like a military campaign. Advance information on wind speed and direction, on relative humidity, and on rain—is a major factor in battlefield strategy. In the Weather Service's Western Region, 18 Fire-Weather Service Offices have mobile units—fully equipped weather stations in a van—that travel to large fires to provide on-the-scene forecast service to fire fighters.

At the Los Angeles Fire-Weather Service Office, in fire-prone southern California, leading fire-weather forecaster, William G. Sullivan and the staff were ready for action during the summer of 1970, but the season passed with ominous quiet. Not a single call for a mobile unit was received in July and only one in August.

Business did begin picking up a little in September. As the month neared its end, the Los Angeles unit had been called out four times, but the fires were neither of long duration nor unusual size. Still, forecasters and fire-control people knew the situation was perilous. Brush and grass parched by the long summer drought awaited the dry east winds that normally begin to blow after mid-September. This deadly combination had set the stage for many large fires in the past.

On September 25, 1970, the truce was over. Nature launched her attack on California. That Friday morning, arid Santa Ana winds rushed from the northeast across the ridges and down the mountain passes, buffeting the fire lookout towers with sustained wind speeds of 40 to 60 miles per hour and gusts of more than 70 miles per hour.

Forewarned by the fire-weather forecasters, the fire-protection agencies had maximum forces at the ready. Late the previous afternoon, the announcement—"All days off and leaves are cancelled"—had been broadcast over the state forestry radio.

But there is really no defense against a fire running with a

continued

George R. Ellis is a fire-weather forecaster stationed at the National Weather Service's Los Angeles Forecast Office.

Santa Ana wind. Friday morning, two fires started on the inland side of the coastal hills north of Los Angeles and were spreading rapidly southward and westward. The first soon reached Malibu, site of previous disastrous fires that had been stopped only at the beach. The second fire, starting farther north near Newhall, quickly burned into heavily populated areas of the San Fernando Valley.

The Malibu and Newhall fires later burned together and soon were augmented by the 35,000-acre Simi fire in southern Ventura County. Thickly settled Topanga Canyon was threatened repeatedly, but the fire lines above it held. To the north of Malibu, the fire rushed toward the beach on a four-mile-wide path. The Los Angeles County Fire Department, the world's largest county fire-fighting organization, used 89 of its 165 companies on this blaze, which nevertheless destroyed 403 houses and 195 other structures. The total area burned in Los Angeles County eventually exceeded 100,000 acres.

The week that followed proved to be a nightmare. In southern and central California, more than 524,000 acres burned; more than 560 buildings, nearly 400 of them dwellings, were destroyed; 13 lives were lost.

To aid the embattled California forecasters, Western Fire-Weather Coordinator W. R. Krumm was to send in men from other stations in the region—Charles E. Syverson from Boise; Lester P. Mallory and the Salt Lake City mobile unit; Robert Allen from Phoenix; Richard Hambidge, Reno; Rex Hess, Sacramento; Albert G. Oertel, Redding; and James Tyrell, Medford. San Francisco's mobile unit, manned by William Ahl, went to the Buckeye Fire, Roger Hegstrum and the Fresno unit to the 35,000-acre Walker Basin fire.

Work at the Los Angeles fire-weather office went on as usual on Friday, the first day of the fires. Major outbreaks were still mostly in county-protected areas. On Saturday, Sullivan set up 12-hour shifts, to provide 24-hour office coverage. From then through the following Sunday, he and fire-weather forecaster Donald V. Lust worked 12- to 16-hour shifts to give continuous backup service to mobile units in the field.

About four o'clock that afternoon, the first request for a mobile weather unit came in—from the Cleveland National Forest, where a rapidly growing fire in eastern San Diego County was threatening the town of Pine Valley.

I took the latest weather charts, transferred my fire clothes from the trunk of my car to the radio-equipped fire-weather van, and headed south on the San Diego Freeway.

It was dark before I came to the first roadblock east of San Diego, near the town of Alpine. The highway patrolman was reluctant at first to allow a camper into the danger area, but he waved me on when he saw it was a government vehicle. Ahead, the sky glowed red. In the air, there was the smell of smoke. Nearing Pine Valley, I could feel the boxy camper swerve in the gusts of dry east wind. At another roadblock, no one knew where the fire camp was. I was told to proceed at my own risk.

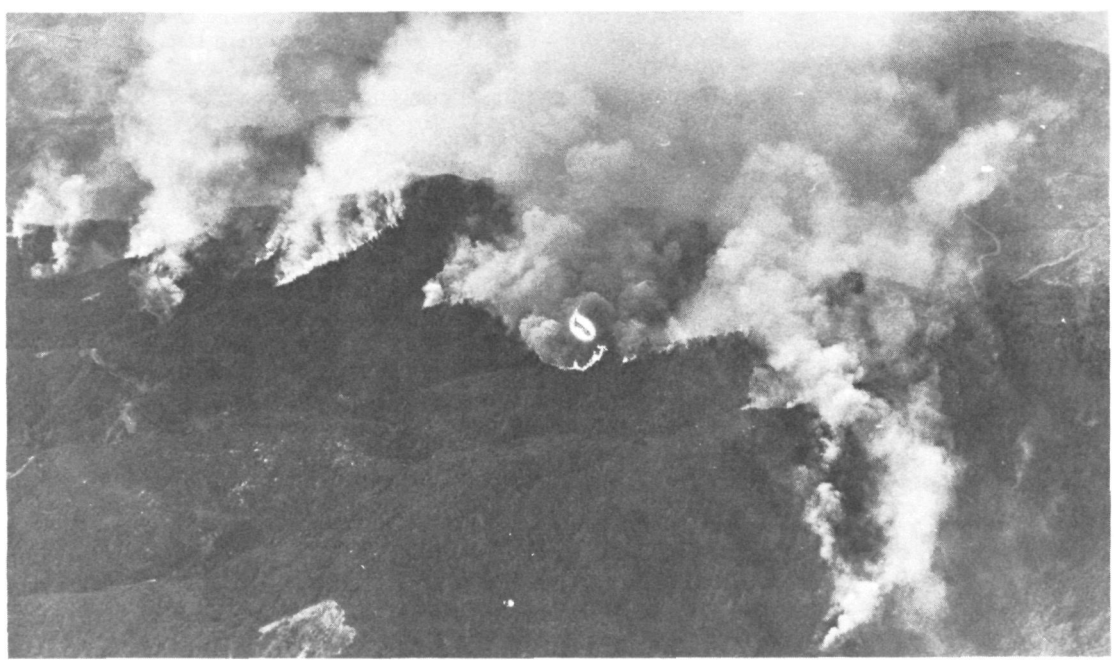
Beyond Pine Valley, the darkness was livened by embers of burned-out trees and brush swirling and dancing across the road with a kind of macabre gaiety. Rolling up the car windows against the sparks and smoke, I continued eastward through the burned-out area until I found a power company crew replacing light poles. They directed me to the fire camp, a few miles up in the mountains.

Finally reaching Forest Service headquarters at Crouch Meadows fire camp, I reported to the plans chief and, fortified with a cup of coffee, began writing out Forecast Number 1 for the Laguna fire, a blaze destined to consume 185,000 acres and become the second largest in recorded California history.

At daybreak Sunday morning, I set up my radio antenna and callel Los Angeles. The weather was leading the forecasters a merry chase. In addition to the normal but devastating Santa Ana, a complication had developed in the form of an upper-level "low" over Arizona and northwest Mexico. Balanced by a second "low" far to the west over the Pacific, with an upper-level "high" mushrooming between the two, it formed part of a classic Omega block. Unable to escape the block, the Arizona "low" wobbled restlessly, first one way and then another, like an eddy in a stream of water.

As this low intensified, the east winds in interior San Diego County reached gale force. Night crews huddled in sleeping bags, wherever they could find shelter. On Monday, the kitchen crews gave up trying to serve lunch and issued box lunches to be eaten in sheltered spots in the lee of trees or fences, or in truck cabs. It was snug enough inside the fire-weather van, but the little vehicle shuddered and swerved in the 60-mile-per-hour gusts. Fortunately, the radio antenna held, communications were uninterrupted, and the business of forecasting continued.

With the winds driving the fire to the west, it was eating its



Arid Santa Ana winds rushed from the northeast across the ridges and down the mountain passes. There is really no defense against a fire running with a Santa Ana wind.

way steadily toward the suburbs of San Diego. The California Division of Forestry requested a second weather unit for the Laguna blaze.

Charles Syverson, who had been sent from Boise to help in the emergency, took the Los Angeles office's second radio-facsimile-equipped camper unit to Monte Vista, just beyond the fire's western edge. Using the fire-weather transceivers, he and I coordinated our thinking on weather developments in the light of guidance received from Los Angeles.

Living and working in a mobile van has one advantage over an office assignment during such a crisis. Your bed is right in your office, and you don't waste time commuting.

In fire camp, the day began with the ringing of the alarm at 1:30 a.m.—time to begin preparing the morning forecast. A quick look at the sky and the hygrothermograph trace, a check of the wind, and I was ready to call Los Angeles for a briefing. Having copied the latest table of pressure gradients, jotted notes from the district forecaster's guidance, picked up the latest surface observations—and a description of the latest prognostic charts if they had not come in on the receiver during the night—I hurried back to prepare the morning forecast, sipping a can of juice or a paper cup of coffee from the camp kitchen.

About this time, the fire-behavior specialist would come in and begin asking questions. As soon as the written forecast was ready, we considered how it would affect the fire. The weather and fire-behavior predictions then were turned into the plans office. They were duplicated and distributed to the day crews leaving for the fire lines at 5 a.m.

If things went well, I could get back in the bunk for another nap before daylight and the activity in the camp aroused me again. Then another look at the sky and the instruments, adjustments to the facsimile receiver to record the new surface map, a run over to the kitchen to pick up breakfast on a paper plate, so I could eat it while copying the morning upper-air soundings and other local data from the radio. Another forecast was needed by 3:00 in the afternoon for the night crews.

In the evening, I felt it was necessary to stay up until 9 or 9:30 to plot the evening radiosonde soundings and to look at the upper-air charts coming in on the facsimile. In this way, I could better evaluate the possibility of a weather change sneaking in during the night.

After setting the radio in the hope of receiving the midnight set of charts from the National Meteorological Center, I would climb into the bunk. With luck, I could sleep till 1:30 a.m.

There was always plenty to do in the fire camp. The forest supervisor, fire boss, kitchen helpers, or tired dirty crewmen just back from the line would look in the back door any time to ask a question or offer a comment. They all had a vital interest in the weather, and forecast errors did not go unnoticed. Crises were frequent: a request for a long-range outlook right away, for an important fire strategy meeting; the need for a quick decision on whether to revise a forecast. What about those radar echoes across the Mexican border? Are they a lightning threat? Should the plans chief be told right away or should I wait an hour or two? The forecaster's body might rest a few hours, but the mind was never at ease.

By Friday, October 2, the Arizona "low" had gathered considerable moisture into its circulation and made a push to the westward, in another attempt to break through the blocking ridge. The dark clouds that greeted my eyes Friday morning were welcome indeed. Only a few drops of rain fell in San Diego County that day, but the humidity stayed high enough to slow the burning.

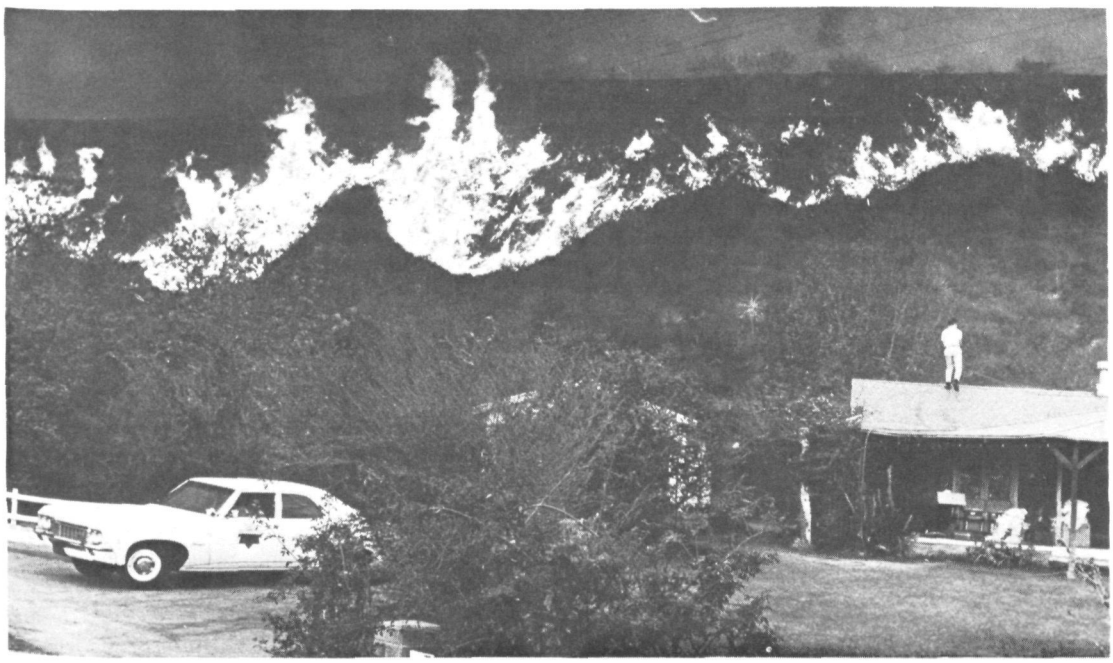
With evening chores done, I climbed into the bunk a little before 10 p.m. Before falling asleep, I heard the sound of thunder. The possibility of thunderstorms had been mentioned in the forecast, but the threat of new fires from dry strikes makes a fire-weather forecaster uneasy.

It was not till I went outside after midnight and smelled the damp ground that I realized a light shower had fallen while I was sleeping. The sky was clear, but radar echoes to the east of the mountains promised more moisture.

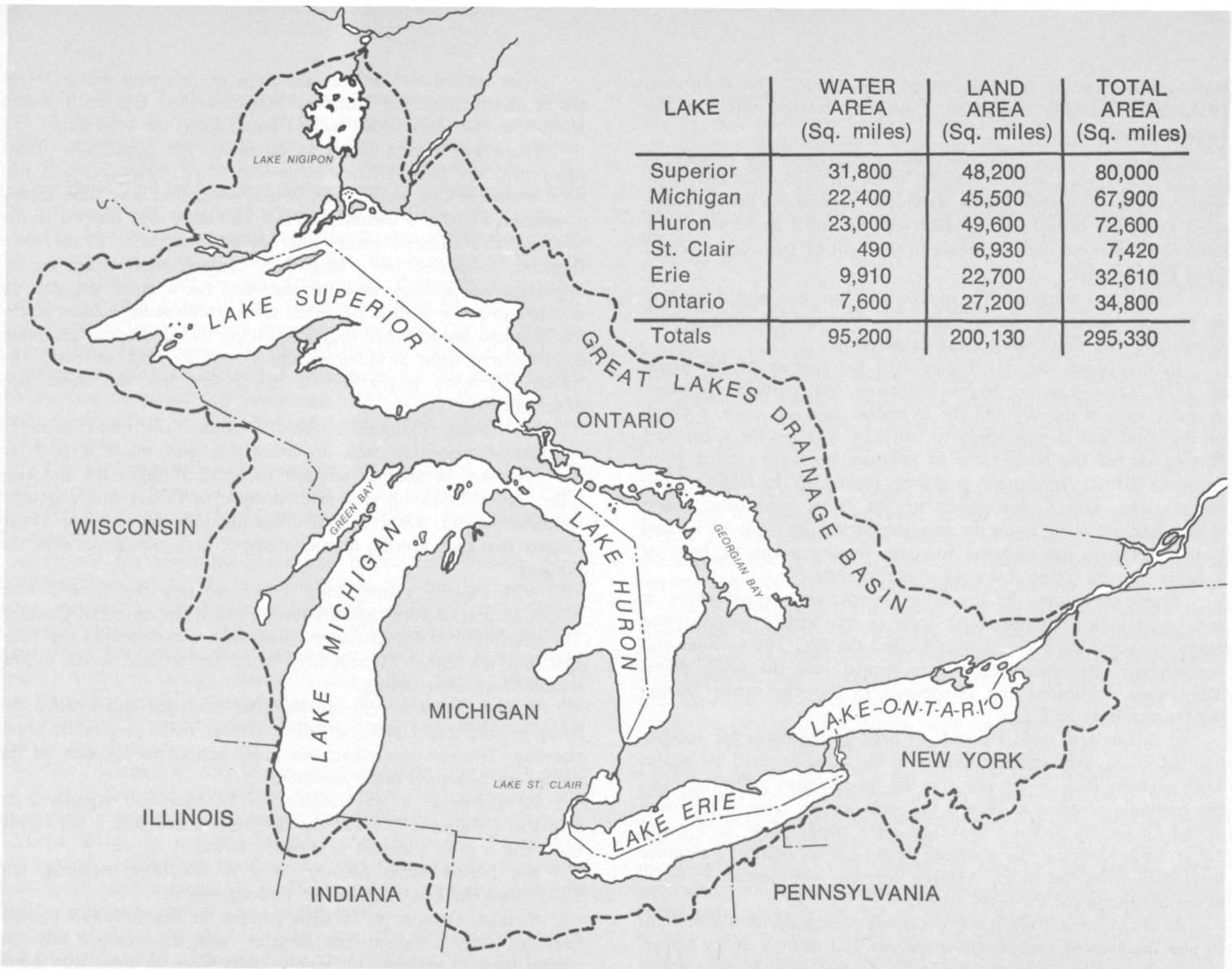
At daybreak, it was raining. In 13 years of experience in southern California this was the first time I had had a fire rained out—and a most pleasant experience it was.

My release came quickly, at 9:30 Saturday morning, and I was back in Los Angeles by mid-afternoon.

Sunday, October 4, brought patches of fog followed by dim sunlight, a quiet day in Los Angeles, with fire-weather activities almost back to normal. All mobile units were on their way home or already parked at their base stations, a bit dusty and cluttered, but ready for more action if needed.



On September 25, a Friday morning, two fires started north of Los Angeles, and spread rapidly southward and westward into heavily populated areas of the San Fernando Valley and Malibu.



LAKE	WATER AREA (Sq. miles)	LAND AREA (Sq. miles)	TOTAL AREA (Sq. miles)
Superior	31,800	48,200	80,000
Michigan	22,400	45,500	67,900
Huron	23,000	49,600	72,600
St. Clair	490	6,930	7,420
Erie	9,910	22,700	32,610
Ontario	7,600	27,200	34,800
Totals	95,200	200,130	295,330

Shippers, power producers, and land owners look to NOAA's Lake Survey Center for information on Great Lakes water levels.

HIGH AND LOW

BY JOHN HANNA
Lake Survey Center

"Banks full" is the outlook for the Great Lakes this year, and shore property owners are gravely concerned about the high water levels.

The levels of the lakes are at once a blessing and a bane to the area populace. Though these levels are constantly changing, the average person pays little attention to them unless they directly affect him during periods of extremes.

When the lake levels are high, they're a boon to commercial shipper and to those power interests that use the outflows of the lakes for hydroelectric power generation.

To the shipper, high water means he can load his ship to the maximum allowable draft, a matter of real money in his pocket. Each additional inch of water available allows another hundred tons of cargo to be loaded.

To the power interests, high lake levels represent extra water for increased power production. This is particularly important to today's "electric" society.

The recreational boater finds the high levels both a help and a hindrance—a help because he can reach places he couldn't during periods of low water, and a hindrance because his highriding boat may not be able to pass under low-level fixed bridges leading into the lakes, and formerly visible sand bars and shoals may be hidden by deeper water.

The riparian property owner bears the brunt of both extremely high and extremely low levels. During high levels, he is exposed to the damage of flooding .and erosion caused by wave action. He sees his beach swallowed up, his land ravaged and torn away by the relentless waters, and his docks and other structures submerged or washed away. On the other hand, with low water depths, his beach creeps further and further away, his small boat harbor may become too shallow for him to enter, and his shoreline substructures are exposed.

What causes the lake levels to rise and fall? Where does the water come from? Where does it go? Can anything be done to prevent extreme highs and lows with their inherent damage potential? These are some of the questions the Lake Survey Center and other organizations have been studying for a number of years.

The Great Lakes contain the world's largest supply of fresh water. They hold nearly 5,500 cubic miles of water—enough to cover the entire United States to a depth of nine feet—and their water surface area stretches nearly 100,000 square miles.

The principal source of supply for this huge system is the precipitation that falls on the lakes and their basins. Great Lakes precipitation averages about 31 inches a year. One inch of rain over one square mile is equal to 16.6 million gallons of water, and the Great Lakes drainage basin area covers about 300,000 square miles. Thus, more than 154 trillion gallons of water fall on the Great Lakes and their drainage basins in an average year.

Precipitation on the lake surfaces is a direct contribution to the water in the lakes. The lakes will rise in an amount almost equal to the precipitation falling on their surfaces.

Additional water comes from the lakes' drainage areas. This indirect contribution also varies with the precipitation, the amounts reaching the lakes as runoff being controlled by several factors—evaporation, evapo transpiration, and absorbed soil moisture. Incidentally, more rain reaches the lakes during early spring and late fall, because most plant life is comparatively dormant during those periods.

While flow from rivers and streams is the most apparent means of supply other than direct precipitation, there are several additional ways that the Great Lakes get water. Among these are diversions into the lakes

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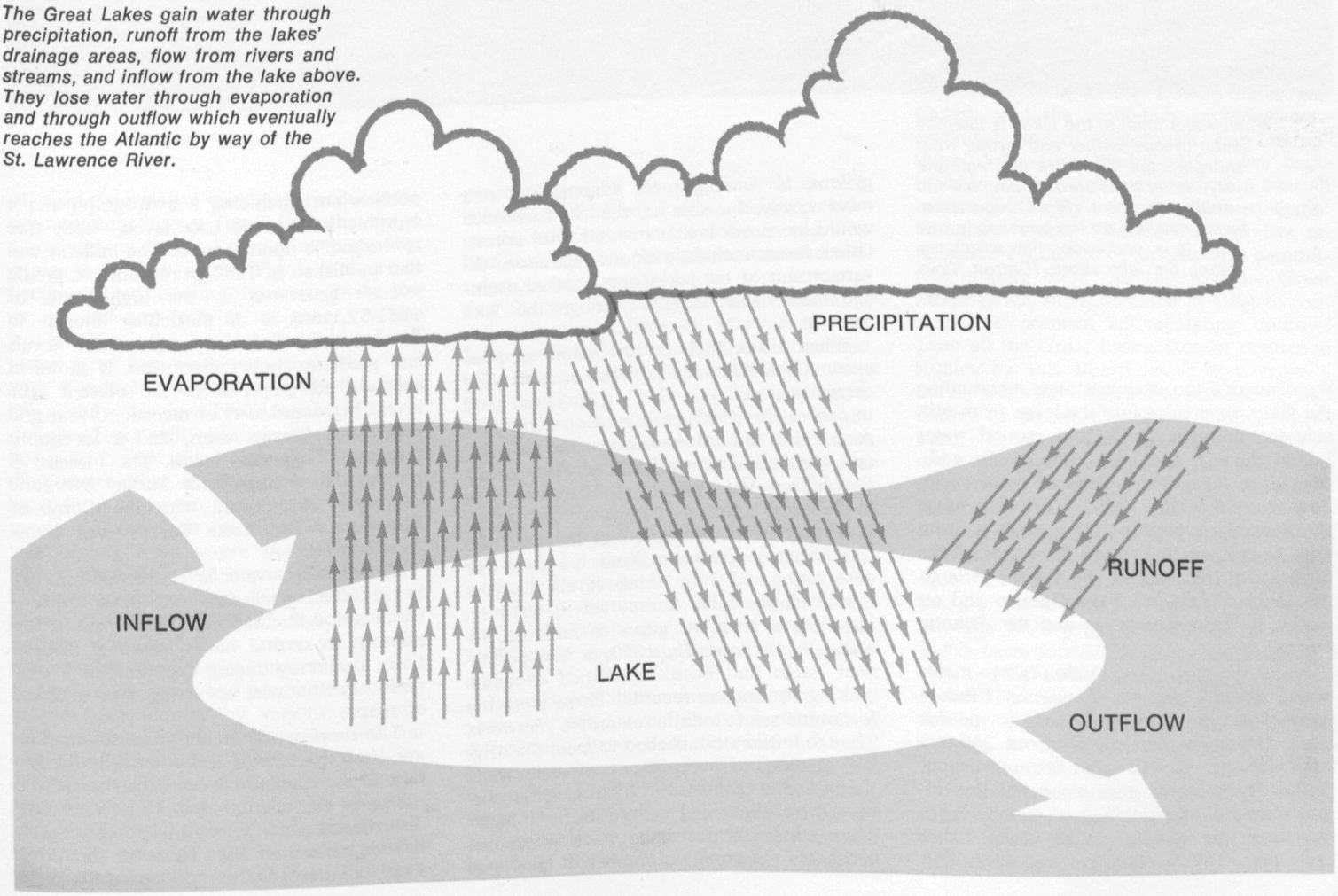
The Great Lakes gain water through precipitation, runoff from the lakes' drainage areas, flow from rivers and streams, and inflow from the lake above. They lose water through evaporation and through outflow which eventually reaches the Atlantic by way of the St. Lawrence River.



When water level in the lakes is low, the beach creeps farther and farther from shore homes, piers are left high and dry, small boat harbors become too shallow to enter. (Right) High water levels swallow up the beaches, erode the land, and undermine structures along the lake shore. (Detroit News photo)

from outside the drainage area surrounding the lakes, diversions into the lakes from outside the drainage basin, and ground water inflow through the lake bottoms. In addition, each lake below Superior receives inflow from the lake above. This is because the downward slope of the system is from west to east, so that water flows from Lake Superior at the head of the system through the chain of lakes to Lake Ontario and on to the St. Lawrence River and the Atlantic Ocean.

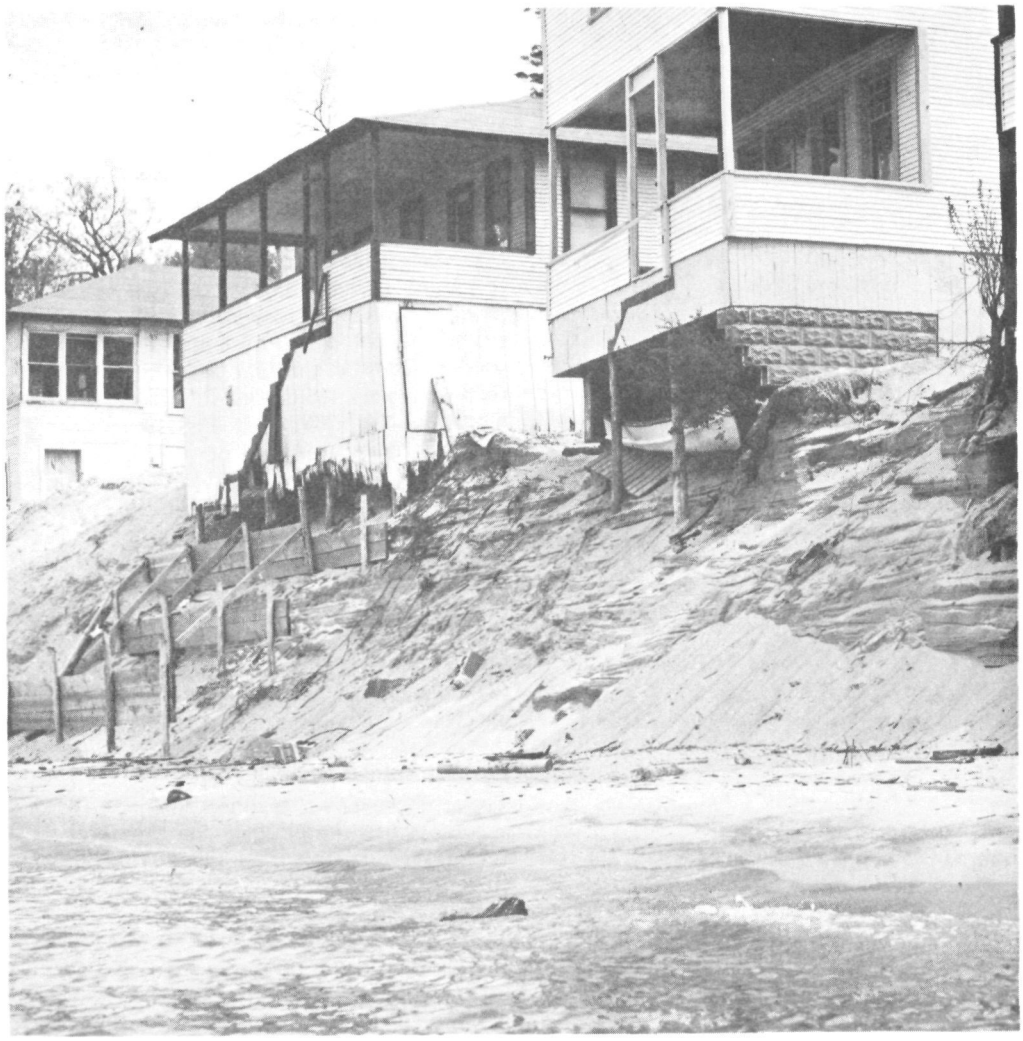
Water leaves the Great Lakes in two major ways: through the St. Lawrence River—which flows out of Lake Ontario to the Atlantic Ocean at the rate of about 240,000 cubic feet per second—and through evaporation. Hydrologists have estimated that almost two-and-one-half feet of water evaporate from the surface of the Great Lakes each year. This is equal to over 42 trillion gallons. If it weren't for evaporation, two more rivers the size of the St. Lawrence would be needed to carry off this excess. Other losses include evapotranspiration, diversion out of the lakes into another drainage basin, and seepage through the lake bottom.

When either high or low water supplies occur for an extended period, corresponding extremes develop in the levels. These tend to persist after the factors causing them have returned to normal, because of the vast size and physical characteristics of the system. But, high or low, these levels affect everyone in the area.

Almost from its beginnings in 1841, the Lake Survey Center realized the need for observation and study of lake levels. To meet this need, the Lake Survey set to work on installing a series of gages to measure the water fluctuations. By 1859, a few permanent gages had been established to begin making continuous records. These were the forerunners of today's extensive network. Though initially established to meet the original missions of investigation of water level changes and control of hydrographic surveys, these gages have proved useful in many other efforts. From them have come the basic data to compile a number of lake level publications, including a hydrograph and a monthly bulletin of lake levels—both free to the public upon request. The bulletin was first published in 1952 in response to public interest generated by the high levels of 1951-52, and is of particular interest to those seeking knowledge of present levels and predictions on their future. It shows in easy-to-read graph form the present lake levels, highs and lows of record, 10-year and long-term average levels, and a six-month forecast of expected levels. The forecast is provided by former Lake Survey hydraulic engineers who stayed with the Corps of Engineers when Lake Survey was transferred to NOAA.

Great Lakes water-level fluctuations can be classified generally into three types—short-period fluctuations, lasting from a few minutes to several hours; seasonal fluctuations, occurring during one year; and long-period fluctuations, occurring over a period of years.

The short-period or abnormal fluctuations are often spectacular and potentially dangerous. These oscillations are called seiches. A seiche is the continuation of a water-level disturbance after the external forces causing it have ceased to act. Those in the Great Lakes area are, for the most part, the result



of severe storms on the lakes produced by the numerous intense squall lines that move across central North America on paths that converge in that region. The lake's surface becomes tilted, causing the water to be low at one end and high at the other. As the forces abate, the natural reaction of the water is to flow back toward the low end with a motion comparable to the "sloshing effect" of water in a broad, shallow pan.

Lake Erie, with its general southwest-northeast orientation and shallowness, is most susceptible to this phenomenon. Its location is close to the mean wintertime position of the polar front and exposes it to wind action from severe storms, many of which reach their full intensity in the area. In extreme cases, these "wind tides" have caused the water to be 13 feet higher at Buffalo than at Toledo, cities at opposite ends of the lake's longitudinal axis.

These fluctuations had been noted as early as the 17th century by various explorers who attributed them to the moon and sun and called them tides. By the 1830's, however, the belief was expressed that though an astronomical tide did exist, it was very small, and that the winds and variations in barometric pressure must be the real forces behind these changes. Modern studies have proved this right; investigations by the National Ocean Survey indicate that true tides on the lakes are less than two inches. The National Weather Service has achieved considerable progress in seiche forecasting so that the public, and particularly shoreline property owners, may be forewarned. The Lake Survey Center has studied the effect of seiches on restricted channels and harbors on the lakes, so that shippers and recreational boaters will not be trapped by unexpected waves or currents. In areas such as the mouth of the Detroit River and other sites where low waters are particularly dangerous, low-water warning lights have been erected and periodic radio broadcasts are made to advise mariners of the depths available in the area.

Seasonal fluctuations, those which occur during one year, are the most predictable. High levels occur regularly in the summer and lows in the winter.

Long-period fluctuations span periods of years. As yet, no definite cycles for these fluctuations have been detected by Lake Survey engineers, despite the popular belief in 7-year and 11-year cycles. The records show only one thing for sure—periods of high water have occurred before and each has been followed by a period of lower levels. The last period of record high levels was in 1952, when erosion and flood damages were estimated at about $62 million. The last low levels occurred in 1964.

When levels begin to rise, as they are doing now, or to fall dramatically, the cry goes out for regulation. Outflows from two of the lakes are regulated—Lake Superior since 1921, and Lake Ontario since 1960—thus achieving some control of levels. But any artificial control must be thoroughly studied before being instituted, since the Great Lakes' levels involve the interests of both Canada and the United States and affect shore property, navigation, and power—three groups whose interests do not always coincide. The effects of any given plan, therefore, require intensive study and testing over extended periods of time to evaluate just how the plan would affect all of these individual interests.

Because the Great Lakes are of such vital importance to both the United States and Canada and the regulatory problems concerning them are so complex, the International Joint Commission (IJC) was organized in 1911 to exercise jurisdiction over all matters pertaining to the use of these shared boundary waters. The Commission has established a number of boards and committees, among them the International Great Lakes Levels Board, created in 1964 to consider the problem of regulating outflows from all the Great Lakes. Recent regulation studies by this Board show that, from a purely technical engineering standpoint, regulation of the entire system is feasible. However, the costs and benefits of such a complicated project must be evaluated completely before any such steps can be undertaken.

What does the immediate future hold?

The 1970-71 winter's abnormal ice and snow have been reflected in the form of rising levels recorded in the Monthly Bulletin. The 1970 precipitation over the Great Lakes basin totaled 34.25 inches, compared with a 1900-1970 annual average of 31.50 inches. The first two months of 1971 added another 5.12 inches of snow, against an average of 3.91 inches during the same months in 1970.

From all indications, and barring some unforeseen caprice of nature, the 1971 Great Lakes water levels probably will be higher than they were in 1970. □

Harris collects an air sample in wintry Yellowstone Park. The samples were later analyzed to determine their carbon dioxide content.

Scientists studying the winter environment at Yellowstone National Park were cautioned . . .

please don't step on the algae

BY THOMAS B. HARRIS

I must admit I felt a little like a science fiction character as I stumbled out of my bunk that first morning in Yellowstone National Park in the height of winter. The eerie qualities of the frosty Norris Geyser Basin were magnified by a coyote's plaintive howl but, despite the chill, I managed to remember that I was there as a member of the 11th Yellowstone Field Research Expedition, with an opportunity to pursue my work in the Atmospheric Physics and Chemistry Laboratory on air cleanliness in the clean, crisp air of high, uninhabited, northwestern Wyoming.

Thomas B. Harris is on the staff of the Atmospheric Physics and Chemistry Laboratory in Boulder, Colo.

Dr. Vincent Schaefer of the State University of New York at Albany has been taking atmospheric research groups into Yellowstone on a near-routine basis for more than 10 years. In addition to providing a clean, uncontaminated winter atmosphere for study, the Yellowstone geyser areas afford a unique opportunity for small-scale, easily studied cloud-seeding experiments.

Geyser eruptions in the cold, heavy air of winter produce a constant, low-level cloud over the geyser basins. This cloud is separate from any surrounding weather and thus is readily isolated, seeded, measured, and studied as a "single system." Usually, the group settles in the Old Faithful area, but this year park construction plans required a move to the Norris Geyser Basin. My work was different since I was not concerned with the geyser basin's cloud but with the cleanliness of the air in a stable, winter environment hundreds of miles from the nearest direct pollution source.

In studies of the world's global atmosphere we need many diverse samples. Winter Yellowstone, far removed from pollution sources and scarcely influenced by the presence of a dozen men, should yield a "clean air" sample of the same quality as those obtained in Antarctica and on the ice stations "in orbit" around the Arctic ocean. To verify my own readings and to provide a comparison sampling in the same general geographic location, I arranged with the Air Resources Laboratory contingent at Idaho Falls for samples to be taken concurrently with mine in Yellowstone.

Air cleanliness in remote field locations can be determined by measuring three parameters—total oxidant, turbidity, and carbon dioxide in the air.

Total oxidant is a measure of the total volume oxidizing agents, such as hydrogen peroxide, acyl peroxides, alkyl hydroperoxides, peracids, and nitrogen oxides, in the surface environment. An electrochemical concentration cell (ECC) oxidant meter should be able to monitor the oxidizing agents of air quality nearly continuously. ECC cells also sense ozone in the absence of other oxidants.

Turbidity, an atmospheric physics term describing the degree of disturbance caused by foreign particles—such as pollen, terpines, sea salt, smoke, and soot—can be measured with an instrument called a voltz sunphotometer. These instruments are in routine use at a worldwide network of observing stations operated by the Environmental Protection Agency, so my week-long study of turbidity at Yellowstone was to be an interesting addition to global measurements.

Atmospheric carbon dioxide could not be measured directly, so I set off from Boulder to Yellowstone with a huge case of sampling bottles to gather air samples for later laboratory analysis for carbon dioxide in Boulder.

Our stay at Yellowstone was to be from January 27 to February 3. Getting there was a project in itself, because winter had long before closed down the park. We had to start from Idaho to get to Wyoming. Our party collected in the Bonneville Hotel in

Idaho Falls, Idaho, the night before. I arrived earlier in the day to co-ordinate my research with ERL's unit at the National Reactor Test Station.

The actual air distance between Idaho Falls and Norris Geyser Basin is only about 125 miles. But, it is a long, bumpy 125 miles, as we learned the next day. We pulled away from the hotel at 6:30 a.m., two station wagons loaded with men and gear. At West Yellowstone, 110 miles away, we welcomed a chance for a lunch break.

When the Yellowstone Company's two-tracked snow vehicles arrived to take us the rest of the way, we realized we had been better off cramped in the station wagons. Most of the gear and supplies for a week's stay fit into one of the snow cats, leaving the other for the 12 of us.

Bedtime varied with the seminar. Each evening, two of our group were slated to give talks and the discussions following these talks went on until everyone was hoarse.

There were only about two feet of snow on the ground and no appreciable amount fell while we were there. Cloudiness was prevalent and temperatures were above normal—ranging a few degrees on either side of zero centigrade.

My measurements of air cleanliness produced some interesting results.

Carbon dioxide samples were taken in pairs to control the accuracy of the sampling techniques. If a pair collected at the same time and place do not agree within 0.8 parts per million carbon dioxide content, we know that something was wrong in that sampling. Many things can cause errors in carbon dioxide sampling, so the pair method is really necessary.

Similar carbon dioxide samples were taken simultaneously at the National Reactor Test Station, 40 mile west of Idaho Falls on the desert near Arco, Idaho. In three of the geyser basin samples and two from Idaho, the carbon dioxide pairs did not agree within 0.8 ppm. But the other successful samplings indicated an average concentration of carbon dioxide for the Norris Geyser basin of 326.1 parts per million (ppm), with the Idaho samples averaging 326.2 ppm.

Carbon dioxide has long been of interest to atmospheric science, and an established rate of 0.7 parts per million is fairly well accepted as the expected annual increase in carbon dioxide for the "global atmosphere." Taking this expected annual increase into account and calculating what the carbon dioxide content of winter air over Yellowstone should be, my samples were 3.5 ppm higher than the predicted values.

At the same time, Richard Proulx of APCL was taking carbon dioxide samples in presumably clean polar air on Ice Island T-3. As soon as he returned with his Arctic samples, we began to test them for comparison with my Yellowstone data. His sampling—at about 85° north latitude, 92° west longitude—showed an average carbon dioxide concentration of 329.3 ppm. This concentration is 5.5 ppm higher than expected, again allowing for the 0.7 ppm annual increase that numerous references have substantiated. Although our samples from Yellowstone and T-3 are too few to verify any claim that carbon dioxide increases have risen sharply in recent years, they certainly do stand as clear testimony to the fact that the annual rate of increase has not been constant and appears to be increasing.

The driver of our snow cat was very accommodating and willing to stop whenever we wanted—for picture taking or just for getting out of the washing-machine we were riding in. One photo stop was made for an elk herd that ignored our noisy arrival and went on placidly grazing as cameras clicked. It was only a 30-mile trip, but two hours on a snow cat seems much longer. When we finally arrived at the camp in Norris Geyser Basin, the group waiting to leave had an "at last" look on their faces that said they had been ready for some time.

Our quarters consisted of two bunk houses, one bunk house-dining hall combination, and two other small buildings, each with one hole and an incredibly cold metal seat.

Our sleeping arrangements were predetermined. We just had to scout around until we found a bed with the right name on it. This was just to ensure that everybody mixed with everyone else.

Since working in Yellowstone under these rather austere conditions is in itself a project, Dr. Schaefer believes a researcher does his best work his second year. Thus, I will be on the "prime" invitation list next year.

After finding our beds, stowing our gear, and setting up any immediately needed equipment, we adjourned to a delicious welcoming steak dinner and a talk by Tom Henderson, our "ramrod" for the week in Dr. Schaefer's place.

Tom is an old hand at these expeditions. He kept everything moving and controlled the evening seminars. He was responsible for helping us abide by Park rules and spent some time the first night discussing the working conditions we might expect. This included water problems. Drinking and cooking water was hauled from a nearby stream, but we resorted to melting snow on the space heaters for washing. The evening ended with a review of each of our proposed programs.

The next night, a park ranger dropped around to fill us in on how to behave in an isolated geyser basin. Don't molest the wildlife was the first item. Wildlife includes algae. The fragile and beautiful algae around the geyser basin need seven years to repair a thoughtless footstep off the boardwalks.

Except for calorie-packed meals and the stimulating seminars each night, our days went as follows.

At 5:30 a.m., the cook and his helper got up. My roommate, Dr. James Dye of the National Center for Atmospheric Research, and I also got up because we were across the hall from these necessarily early risers. Breakfast could be ordered between 6 and 7 but, before that, many of the cloud-seeding experimenters had rushed out to record the temperature. In the entire week we were there the weatherman was not very cooperative. It was too warm for most of the seeders' liking. On several marginal mornings, the exodus to the geyser basin was quite abrupt as the group rushed out to start work before it warmed up any more.

The Yellowstone geysers afford scientists a unique opportunity for small-scale cloud-seeding experiments.

Mornings were always devoted to our individual projects and an occasional bracing hike around the area. After lunch, it was back to the basin until 4 or 5 p.m. A social hour started at 5 p.m. and continued until dinner.

The ECC oxidant meter didn't like Yellowstone. It ran for one hour and encountered pump problems. So, instead of a nearly continuous record of total oxidant, I had to settle for hourly morning and afternoon samples. Total oxidant, expressed in parts per million, was somewhat low but within the limits expected in the prevailing meteorological conditions of continuing cloud cover, low ventilation, and little vertical exchange.

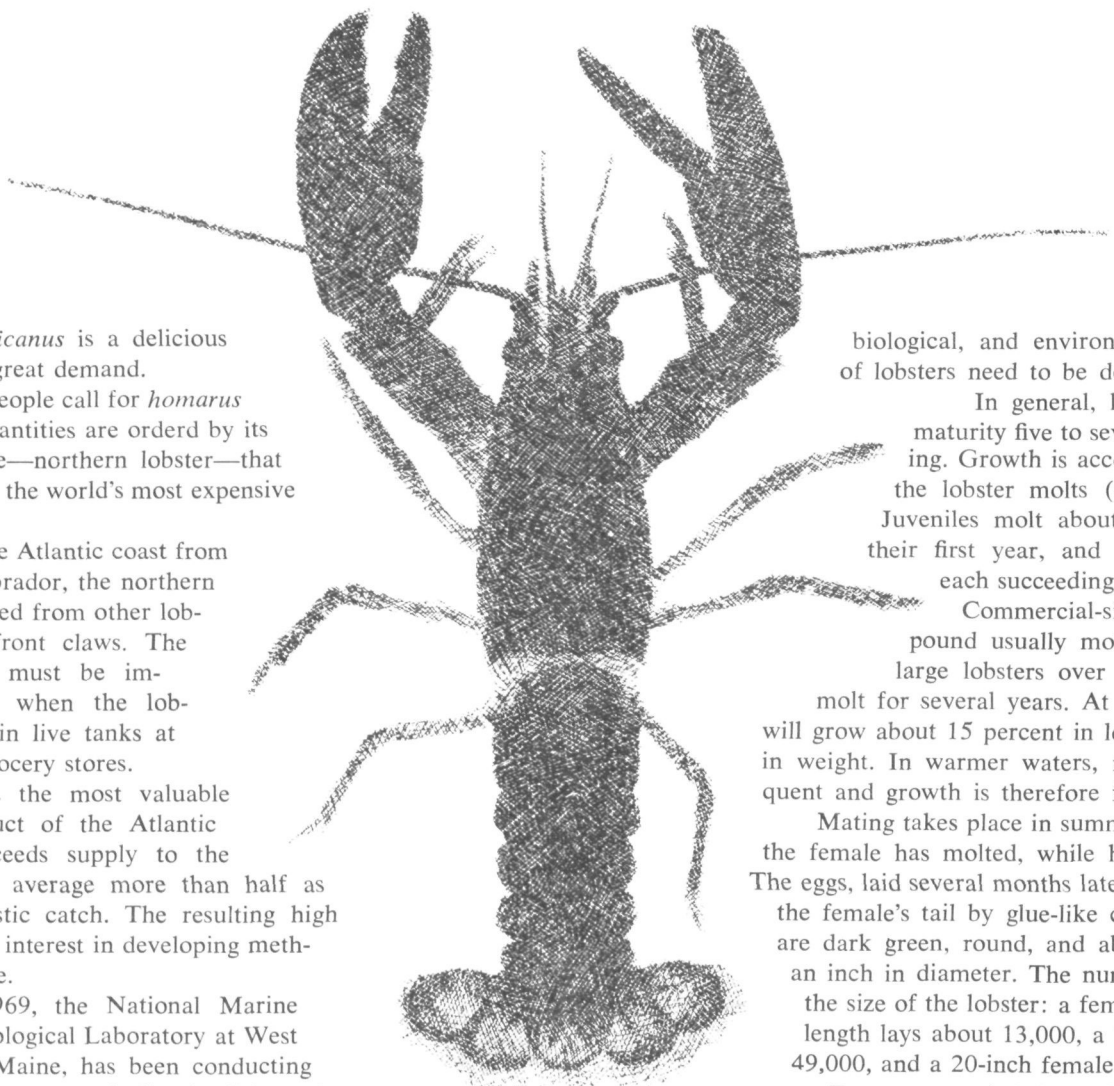
Turbidity measurements also fell within acceptable and predictable limits for the western plains and Rocky Mountain regions. Total oxidant measurements were low which was expected with the continuing cloud cover producing a stable, almost stagnant, winter atmosphere.

From my project standpoint, the 1971 expedition was fruitful and, if I follow Dr. Schaefer's norm, next year's should be even more so. □

COMMERCIAL CULTURE IS THE GOAL OF A NATIONAL MARINE FISHERIES SERVICE RESEARCH PROJECT IN MAINE

BRINGING UP LOBSTER

BY CRAIG B. KENSLER



Homarus americanus is a delicious natural resource in great demand.

Although few people call for *homarus americanus,* such quantities are orderd by its more common name—northern lobster—that it has become one of the world's most expensive seafoods.

Found along the Atlantic coast from the Carolinas to Labrador, the northern lobster is distinguished from other lobsters by its large front claws. The formidable pincers must be immobilized carefully when the lobsters are displayed in live tanks at supermarkets and grocery stores.

This lobster is the most valuable single fishery product of the Atlantic coast. Demand exceeds supply to the extent that imports average more than half as much as the domestic catch. The resulting high prices have renewed interest in developing methods of lobster culture.

Since early 1969, the National Marine Fisheries Service Biological Laboratory at West Boothbay Harbor, Maine, has been conducting research to develop economically feasible techniques for commercial culture operations.

There is no doubt that lobsters can be maintained under controlled conditions. Each year, millions are held in tidal pounds, lobster cars, or tanks of circulating sea water for as long as six months before shipment to market. Newly hatched larvae and juvenile lobsters also can be maintained under artificial conditions.

Although it is not difficult to rear a few lobsters to commercial size on an experimental basis, there are factors that could prevent profitable commercial culture at present.

Some of the more important problems result from the biology of lobsters; they are slow-growing, cannibalistic, and territorial. Maintaining and rearing large numbers in crowded conditions is particularly difficult. High mortalities can be caused by improper diet, bacterial, or parasitic diseases, failure to molt successfully, cannibalism, or unfavorable environmental conditions. Nutritional, biological, and environmental requirements of lobsters need to be determined.

In general, lobsters reach sexual maturity five to seven years after hatching. Growth is accomplished only when the lobster molts (sheds its old shell). Juveniles molt about 10 to 12 times in their first year, and less frequently with each succeeding year.

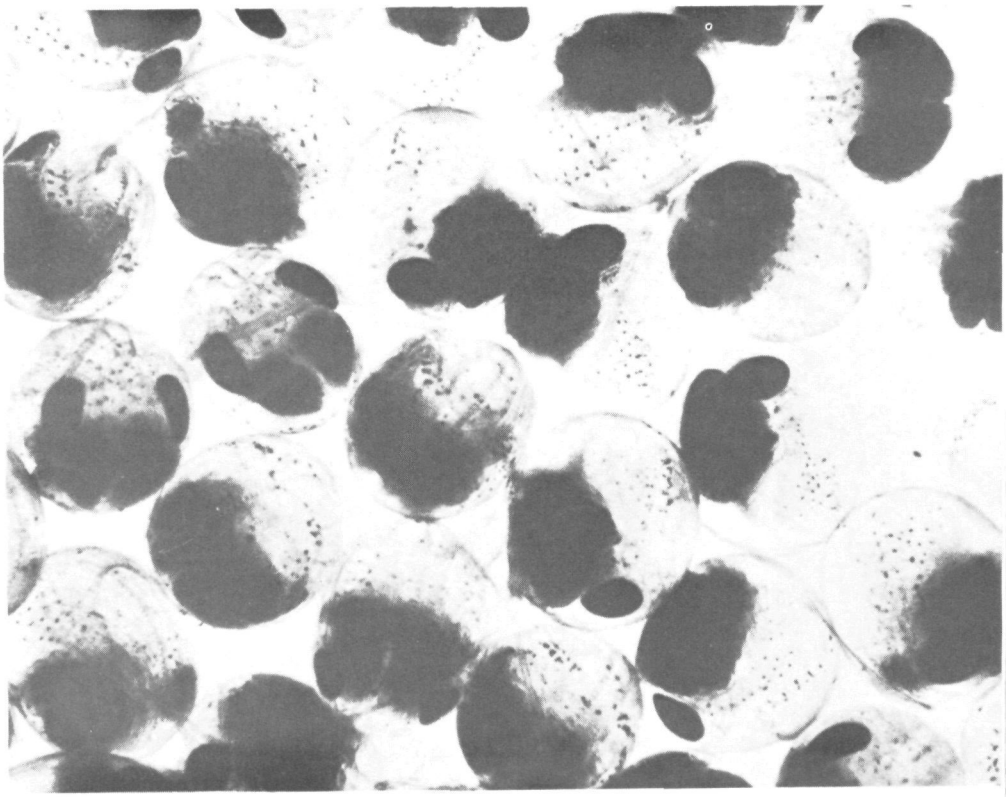
Commercial-sized lobsters of one pound usually molt once a year; very large lobsters over 10 pounds may not molt for several years. At each molt, a lobster will grow about 15 percent in length and 50 percent in weight. In warmer waters, molting is more frequent and growth is therefore faster.

Mating takes place in summer immediately after the female has molted, while her shell is still soft. The eggs, laid several months later, are attached under the female's tail by glue-like cement, and the eggs are dark green, round, and about one-sixteenth of an inch in diameter. The number laid varies with the size of the lobster: a female 10 inches in total length lays about 13,000, a 15-inch female about 49,000, and a 20-inch female about 124,000.

Eggs are carried from 9 to 11 months, and hatching takes place mainly during the summer, depending on water temperature.

Newly hatched lobsters—called larvae—are about one-third of an inch long, free-swimming, and bear little resemblance to their parents. They rise to the surface of the water where they feed on plankton and where they molt three times, changing in form and growing larger at each molt. The fourth and last larval stage is reached 15 to 35 days after hatching. Low water temperature delays molting, as does insufficient food supply. When young lobsters reach the fifth stage, they are about five-eighths of an inch long, have adult characteristics, and settle to the bottom to assume adult habits.

Dr. Craig B. Kensler, formerly a fishery research biologist with the National Marine Fisheries Service Biological Laboratory at West Boothbay Harbor, Maine, is on assignment in Mexico with the Food and Agriculture Organization of the United Nations.



Although a 15-inch female lobster lays about 40,000 eggs (Left), under natural conditions some 99 percent of this potential crop will be eaten by fish and other aquatic animals.
(Top) An enlargement of lobster eggs, nearly ready to hatch. Their actual size is about 1/16-inch diameter. (Bottom) Eight-day-old lobster larvae bear little resemblance to their parents.

Ideally, species for aquaculture should have certain primary qualities to ensure commercial success. They should reproduce under artificial conditions. Eggs or larvae should be hardy and capable of being hatched or reared under controlled conditions. Nutritional requirements of the young should be satisfied by readily available natural foods, unless prepared foods can be used for the early stages. Necessary food items should be cheap and abundantly available. The organism should reach commercial size quickly.

Although the northern lobster does not possess all these qualities, it does satisfy the first three in most respects. In addition, several attributes of the lobster are ideal for culture and could, with further research, develop into exciting breakthroughs. In particular, ease of reproduction and the favorable effect of increased temperature on the metabolism of the lobster emphasize its suitability for culture.

In the past few years, biologists at the Massachusetts State Lobster Hatchery have successfully mated scores of lobsters in captivity, and have hatched thousands of second-generation offspring. The success of selective breeding experiments suggests that further research may soon make it possible to produce fast-growing, disease-resistant lobsters particularly suited for artificial culture, and having commercially desirable characteristics.

The second biological attribute which offers possibilities for future culture success is the favorable effect of increased temperature on the lobster's metabolism throughout its life cycle. Recent work at the Boothbay Harbor Laboratory has demonstrated the ease of accelerating hatching by using warm water. In nature, females carry their eggs about 10 months, but in warm water (up to 80° F.), the egg development rate increases and larvae hatch in less than half the normal time.

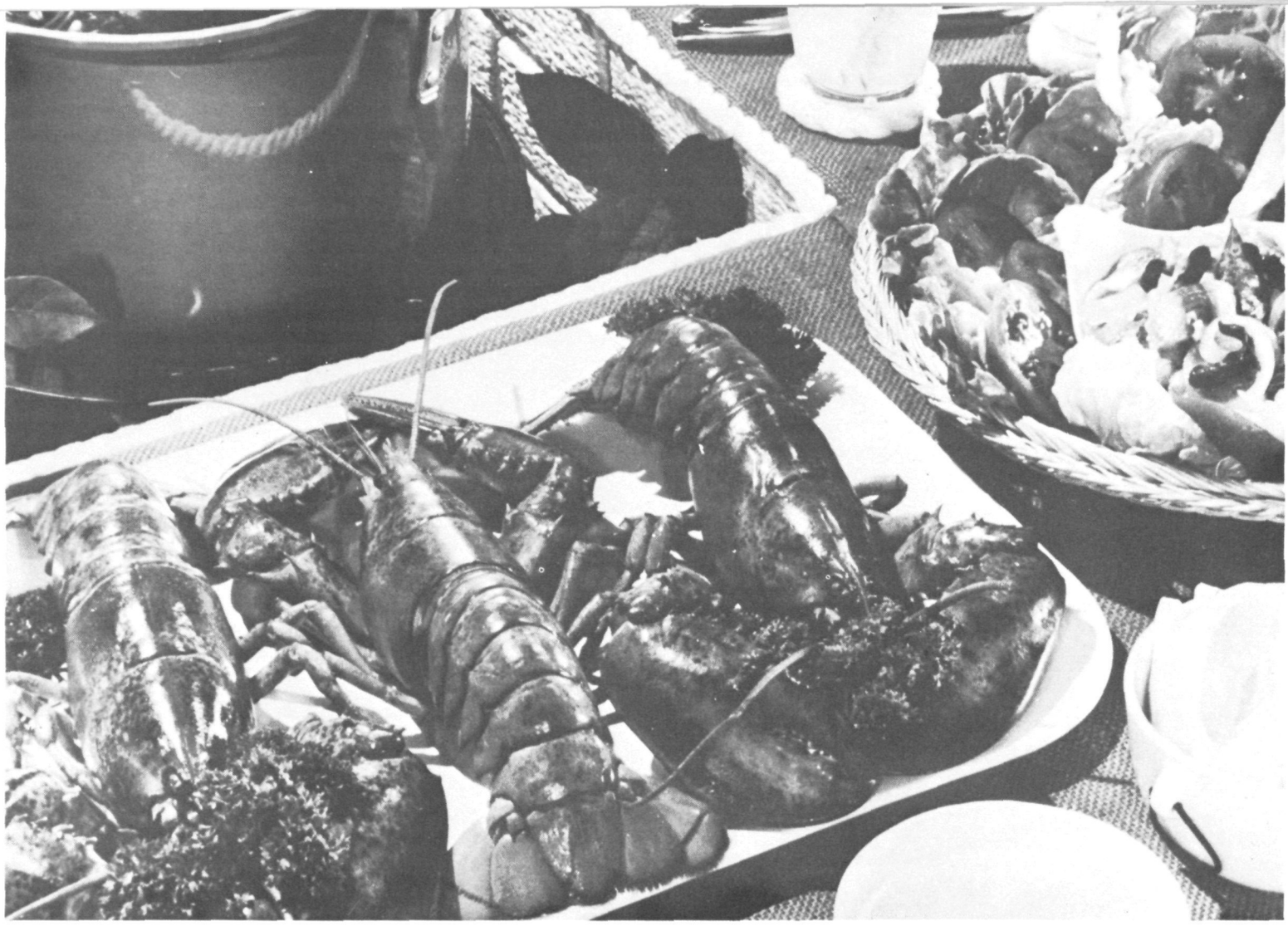
Increased temperatures also accelerate frequency of molting, thus promoting faster growth.

Recent experiments in the United States and Canada have shown that the four larval stages are completed in about 30 days at 55° F, 20 days at 62° F, and in only 10 days at 70° F. Survival of larvae was much better at higher temperatures. Juvenile and subadult lobsters also grow faster in warm water conditions, although optimum temperatures are still undetermined.

Based on these initial findings, there is reason to believe that the five to seven years required to attain commercial size can be reduced significantly by warm-water culture—perhaps by as much as 50 percent.

NMFS studies at Boothbay Harbor are aimed at promoting and accelerating hatching under laboratory conditions; determining environmental and nutritional requirements of laboratory-reared

continued



The northern lobster is in such great demand that it has become one of the world's most expensive seafoods.

larvae and juveniles, and identifying the most favorable rearing temperatures. Future projects include food preference experiments, development of an artificial pelleted food suitable for mass feeding, disease and predator control, and selective breeding experiments.

In 1951 the Commonwealth of Massachusetts established the State Lobster Hatchery on the island of Martha's Vineyard, south of Cape Cod, to rear larval lobsters for release in coastal waters. Since 1951, over seven million small lobsters have been reared and liberated by the hatchery.

Experimental work on lobster culture at the hatchery includes the effect of increased temperature on egg development rates; selective breeding; and artificial diets and foods.

Lobster culture studies by the Fisheries Research Board of Canada involve a research program to investigate transplanting northern lobsters to the Pacific Coast—hopefully to establish a reproducing population. This research is being carried out at Fatty Basin on the southwest coast of Vancouver Island, British Columbia. Since 1965, over 5,500 adult lobsters have been transplanted, as well as several thousand larvae and a number of females with eggs.

An experimental hatchery similar to that on Martha's Vineyard, Mass. was built at Fatty Basin for larval culture studies, and has been in operation since May 1967. Investigations have been designed to study whether physical conditions in the Pacific are satisfactory for normal embryonic development, hatching, larval survival, and growth. Present work includes selective breeding; effect of increased temperature on growth rate and survival of larvae; food requirements of larvae; and formulation of a synthesized pelleted food. The hatchery also provides thousands of juvenile lobsters for planting at other locations.

An academic and industrial group in southern California had been studying the use of warm water effluent from coastal power plants to accelerate the hatching and growing of northern lobsters. The next step is small scale stocking in local waters to study growth, survival, and dispersal.

This research is being conducted in a laboratory on the grounds of San Diego Gas & Electric Company's power plant. San Diego State College, along with the State of California and the utility company, is cooperating in the lobster development program. Besides studies on the effect of increased temperatures on hatching and rearing, the project involves investigations of food requirements, artificial diets, and behavior of newly settled lobsters.

On a lesser scale, several other groups are engaged in lobster culture research, both in North America and overseas.

Workers at Oregon State University are studying the effect of water temperature on survival of northern lobster larvae, with a view to establishing a population in Oregon waters.

The Department of Sea and Shore Fisheries of Maine is compiling and analyzing biological and environmental data from a coastal area subjected to warm water discharge from a power plant, to learn if the area is suitable for lobster rearing.

Private groups in Puerto Rico and Florida have also been involved in limited lobster hatching and rearing.

Biologists estimate that, in the natural environment, some 99 percent of the potential lobster crop is eaten by fish and other aquatic animals while in the free-swimming larval stages. Perhaps the efforts of researchers can help provide hungry human beings with a fairer share of this delectable resource. □

SUMMER COOLERS

The weather outside is steaming, temperatures are soaring, air conditioners are working overtime, and most of us are daydreaming of shady spots and cool breezes. Even if you can't go to the beach—keep your cool by bringing the soothing waters to you with seafood salads and sandwiches.

Crabmeat is especially appropriate at this time of year and may be purchased fresh, frozen, pasteurized, or canned. This delicately flavored shellfish combines readily with other ingredients in summer salads and sandwiches.

Along the Chesapeake Bay and the gulf coast, some of the choicest and most preferred of all crustaceans are soft-shell crabs. These are not a distinct species but are blue crabs in the molting stage. Molting is the discarding of the old, outgrown shell and the forming of a new and larger one. When a fisherman spots crabs about to molt, he sets the "peelers" off in special floats where the process is completed. This takes no more than eight hours, so a careful watch must be kept in order to allow the new shell to harden just enough to withstand shipping. Soft-shell crabs are available live in some areas, with the peak season being July and August. After cleaning and cooking, the entire body of the soft-shell crab may be eaten.

Hard-shell crabs are sold alive in some areas, but the usual market form is ready-to-eat crabmeat. This crabmeat has been steamed, picked from the shell, and refrigerated. It is sold fresh in 12 and 16 ounce cans.

Pasteurization is another market form of crabmeat. This involves processing the freshly steamed and picked crabmeat in cans which are hermetically sealed and immersed in a hot water bath. Pasteurization retains the taste of the fresh product, and does not alter the texture of the meat. Pasteurized crabmeat must be kept under refrigeration until ready to use.

The following seafood sandwich and salad recipes were prepared by the National Marketing Services Office of the National Marine Fisheries Service, for your summer enjoyment.

GRILLED CRAB SANDWICHES

1 pound crabmeat, fresh, frozen, or pasteurized—or
3 cans (6½ ounces each) crabmeat
½ cup shredded cheddar cheese
½ cup chopped black olives
⅓ cup chopped parsley
¼ cup mayonnaise or salad dressing
1 tablespoon lemon juice
¼ teaspoon liquid hot pepper sauce
12 slices sandwich bread
½ cup butter or margarine, melted

Thaw frozen crabmeat. Drain crabmeat. Remove any remaining shell or cartilage. Combine all ingredients except bread and butter. Spread 6 slices bread with crabmeat mixture. Cover with remaining 6 slices of bread. Brush outside of sandwiches with butter. Place sandwiches in a single layer in a hot 12-inch fry pan. Fry at a moderate heat for 2 to 3 minutes or until brown. Turn carefully. Fry 2 to 3 minutes longer or until sandwiches are brown on both sides. Makes 6 servings.

CRISPY CRAB SANDWICHES

12 soft-shell blue crabs
2 eggs, beaten
¼ cup milk
2 teaspoons salt
¾ cup flour
¾ cup dry bread crumbs
6 sandwich buns (toasted if desired)
Tartar sauce

If crabs are not already dressed, cut off the face just back of the eyes. Remove the apron and spongy parts (the gills, stomach, and intestines) under the points of the body covering. Rinse in cold water; drain. Combine egg, milk, and salt. Combine flour and crumbs. Dip crabs in egg mixture and roll in flour and crumb mixture. Cook as directed below. Place two crabs on bottom half of each bun. Cover with tartar sauce and top half of bun. Makes 6 servings.

Pan-Fried: Place crabs in a heavy fry pan containing about ⅛ inch of fat, hot but not smoking. Fry at moderate heat. Brown on one side, turn carefully and brown the other side. Cooking time approximately 8 to 10 minutes. Drain on absorbent paper.

Deep-fat Fried: Fry in a basket in deep fat, 375° F., for 3 to 4 minutes or until brown. Drain on absorbent paper.

continued

SUNNY CRAB SANDWICH

1 pound blue crabmeat, fresh, frozen, or pasteurized, or other crabmeat
1 cup sliced almonds
½ cup chopped celery
½ cup mayonnaise or salad dressing
2 tablespoons lemon juice
6 toasted buttered English muffins
12 cooked asparagus spears (or more, as desired)
6 slices (1 ounce each) cheddar cheese
Paprika
Tomato wedges

Thaw frozen crabmeat. Drain crabmeat. Remove any remaining shell or cartilage. Combine almonds, celery, mayonnaise, lemon juice, and crabmeat. Arrange muffin halves on a cookie sheet, 15 by 12 inches. Place one or more asparagus spears on each muffin half. Cover asparagus and muffin with crab mixture. Cut each cheese slice diagonally into quarters. Place 2 triangles on each sandwich. Sprinkle with paprika. Bake at 400° F. for 15 to 20 minutes or until heated through and cheese is melted. Serve with tomato wedges. Makes 6 servings.

BOUILLABAISSE SALAD

2 cans (7½ ounces each) king crabmeat
2 cans (4½ ounces each) shrimp
2 cans (6½ or 7 ounces each) tuna
3 quarts salad greens
12 black olives
12 tomato wedges
Blue Cheese Dressing

Drain crabmeat. Remove any remaining shell or cartilage. Cut large pieces in half. Drain shrimp. Cover shrimp with ice water and let stand for 5 minutes. Drain. Drain tuna and break into large pieces. Place greens in 12 individual salad bowls. Arrange fish over greens and garnish with olives and tomatoes. Serve with Blue Cheese Dressing. Makes 12 servings.

Blue Cheese Dressing

1 cup oil
½ cup crumbled blue cheese
¼ cup vinegar
2 teaspoons grated onion
1 teaspoon sugar
½ teaspoon salt

Combine all ingredients. Chill. Makes approximately 1½ cups dressing.

SMOKY SEAFOOD SALAD

1½ pounds smoked sablefish or other smoked fish
6 cups salad greens
1½ cups drained cooked peas
1 cup julienne cut Swiss Cheese
1 cup thin red onion rings
⅓ cup mayonnaise or salad dressing
1 tablespoon sugar
¾ teaspoon salt
¼ teaspoon pepper

Remove skin and bones from fish. Flake the fish. Combine salad greens, peas, cheese, onion, and fish. Combine mayonnaise, sugar, salt, and pepper. Pour dressing over salad. Toss lightly. Chill. Before serving sprinkle with bacon. Garnish with cherry tomatoes. Makes 6 servings.

¼ cup cooked crumbled bacon
6 cherry tomatoes

SALMON SCANDINAVIAN

2 pounds salmon, center chunk, fresh or frozen
3 tablespoons salt
3 tablespoons sugar
1 tablespoon crushed peppercorns
½ bunch fresh dill
Mustard-Dill Sauce

Thaw frozen salmon. Cut salmon in half lengthwise. Remove backbone and rib bones. Combine salt, sugar, and peppercorns. Rub ½ spice mixture over 1 piece of fish. Place fish, skin side down, in a glass, enamel, or stainless steel dish, 8 by 8 by 2 inches. Place dill on top of fish. Rub other piece of fish with remaining spice mixture. Place fish, skin side up, on top of dill. Cover with aluminum foil. Place a plate on top of fish. Put a weight on top of the plate. Refrigerate for 48 hours. Turn fish over every 12 hours, separating fillets slightly to baste with accumulated liquid in dish.

When ready to serve, scrape away dill and seasoning. Place fish, skin side down, on a board. Cut salmon diagonally into thin slices away from skin. Serve cold with Mustard-Dill Sauce. Makes approximately 24 appetizers or 6 entree servings.

Mustard-Dill Sauce

¼ cup Dijon-style mustard
3 tablespoons sugar
2 tablespoons vinegar
1 teaspoon dry mustard
⅓ cup salad oil
3 tablespoons chopped fresh dill

Combine all ingredients, except oil and dill, in a small deep bowl. Slowly beat in the oil until a thick emulsion is formed. Stir in dill. Chill. Makes approximately ¾ cup sauce.

CREOLE SHRIMP SALAD

¾ pound cooked, peeled, cleaned shrimp, fresh or frozen
4 cups cold cooked rice
½ cup chopped celery
½ cup peeled, seeded, chopped tomato
2 tablespoons chopped green pepper
2 tablespoons chopped pimiento
3 tablespoons salad oil
2 tablespoons tarragon vinegar
1¼ teaspoons salt

Thaw frozen shrimp. Combine rice, celery, tomato, green pepper, and pimiento. Combine oil, vinegar, and seasonings. Add oil mixture to rice and mix well. Pack rice into a 5-cup ring mold. Chill. Unmold on salad greens. Fill rice ring with shrimp. Serve with Remoulade Sauce. Makes 6 servings.

½ teaspoon dry mustard
¼ teaspoon sugar
Remoulade Sauce
Salad greens

Remoulade Sauce

1 cup mayonnaise or salad dressing
¼ cup chopped sweet pickles
2 tablespoons tarragon vinegar
2 tablespoons water
1 tablespoon chopped capers
1 tablespoon chopped green onion

Combine all ingredients. Chill. Makes approximately 1½ cups sauce.

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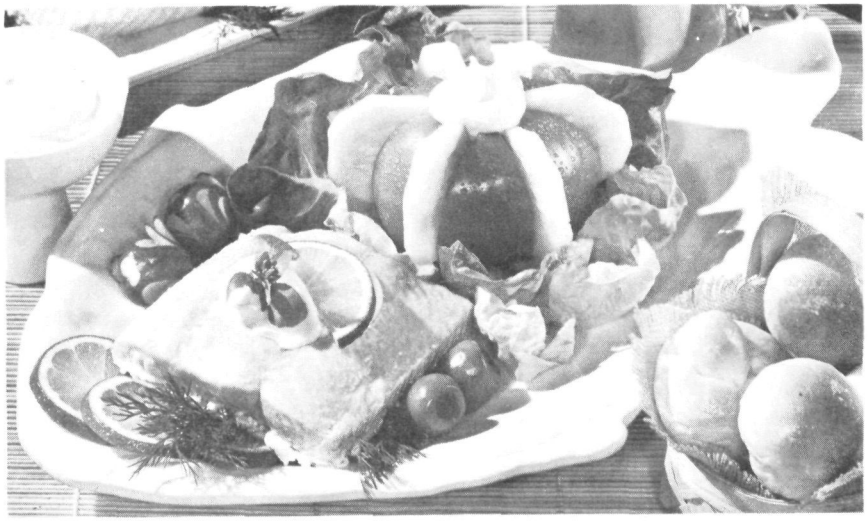
1 tablespoon chopped parsley
1 teaspoon prepared mustard

TAKE-ME-ALONG SEAFOOD SANDWICH

2 cans (16 ounces each) salmon
2 cups chopped celery
1 cup chopped walnuts
¾ cup mayonnaise or salad dressing
1 long loaf (1 pound French bread)
3 dill pickles, sliced lengthwise
1 Bermuda onion, sliced and separated into rings
Lettuce leaves

Drain and flake salmon. Combine celery, walnuts, mayonnaise, and salmon. Chill. Cut bread in half lengthwise, and remove a small amount of the center. Spread each half with salmon mixture. Cut each half into 12 slices crosswise. Serve with pickle slices, onion rings, and lettuce. Makes 12 servings.



SUMMER SALMON

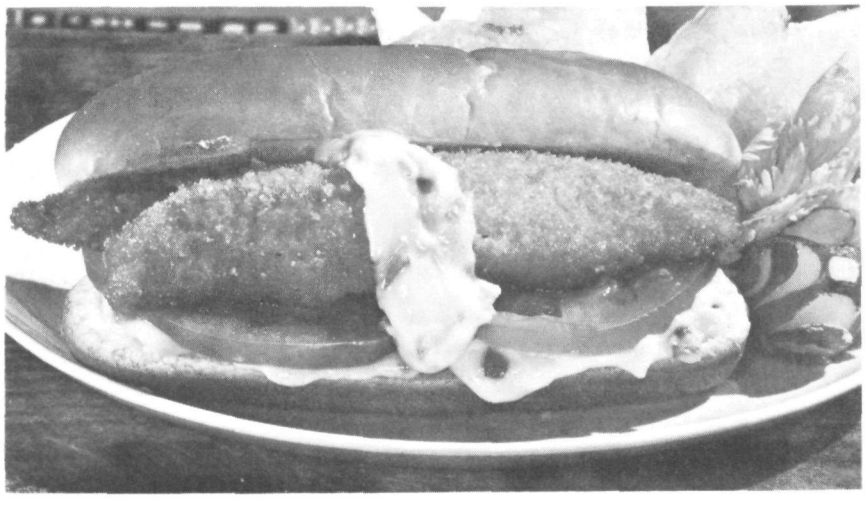
2 pounds salmon fillets, fresh or frozen
2 cups boiling water
¼ cup lemon juice
1½ teaspoons salt
6 slices lemon or lime
Sour Cream-Curry Sauce

Thaw frozen fillets. Remove skin and cut fillets into 6 portions. Place fish in a single layer, in a well-greased 12-inch fry pan. Add water, lemon juice, and salt. Cover and simmer for 5 to 10 minutes or until fish flake easily when tested with a fork. Carefully remove fish to a platter. Chill. Top each portion with a slice of lemon or lime. Serve with Sour Cream-Curry Sauce. Makes 6 servings.

Sour Cream-Curry Sauce

½ cup sour cream
¼ cup mayonnaise or salad dressing
1 teaspoon curry powder

Combine all ingredients. Chill. Makes approximately ¾ cup sauce.



PIRATE'S PRIDE PERCH SANDWICHES

1 pound ocean perch or other fish fillets, fresh or frozen
¼ cup milk
1 egg, beaten
1 teaspoon salt
Dash pepper
1 cup dry bread, cereal, or cracker crumbs
Fat for frying
6 frankfurter rolls
½ cup chopped onion
3 tablespoons mayonnaise or salad dressing
2 tablespoons pickle relish
1 tablespoon prepared mustard
6 slices tomatoes, cut in half
¼ teaspoon salt
Dash pepper

Thaw frozen fillets. Divide into 6 portions. Combine milk, egg, salt, and pepper. Dip fish in milk and roll in crumbs. Place fish in a single layer in hot fat, in a 12-inch fry pan. Fry at a moderate heat for 4 to 5 minutes or until brown. Turn carefully. Fry 4 to 5 minutes longer or until fish are brown and flake easily when tested with a fork. Drain on absorbent paper.

Cut rolls in half lengthwise and remove some of the soft centers. Combine onion, mayonnaise, pickle relish and mustard. Spread on rolls. Place fish on rolls. Cover with tomatoes and sprinkle with salt and pepper. Replace tops. Wrap each sandwich in wax paper. Place rolls on a baking pan, 15 x 10 x 1 inches. Heat in a moderate oven, 350° F., for 10 to 12 minutes or until heated through. Makes 6 servings.

NOAA Laboratory Seeds Florida Clouds In Attempt To Augment Water Supply

A special cloud-seeding project was conducted by NOAA for the State of Florida from April 1 to May 31, in an effort to relieve the worst drought in Florida history.

Before the seeding began, the Central and Southern Flood Control District of Florida reported major water storage areas two to three feet below normal levels. The Cross-Florida Okeechobee Waterway was below navigable level, and fires were sweeping the Everglades and prairielands of south Florida.

When the State requested NOAA's help in increasing its water supply, Dr. Robert M. White, NOAA Administrator, directed the Experimental Meteorology Laboratory to begin a rain enhancement experiment.

The Laboratory, headed by Dr. Joanne Simpson, undertook to increase rainfall by seeding tropical cumulus clouds over a 4,800-square-mile area north of Lake Okeechobee, the reservoir for most of south Florida's water. The area was later extended south of the Lake. Dr. William Woodley of the Laboratory was Project Director, and Dr. James McFadden served as Project Coordinator for the RFF.

Experiments conducted in 1968 and 1970 by EML showed that on relatively fair days dynamic seeding of single clouds produced seven times the rainfall of unseeded clouds and suggested that seeding may promote the merger of clouds, thus enhancing their rainfall over limited areas as much as 10 to 20 times. The special project attempted to concentrate on the more productive cloud merging, since even very successful single-cloud seeding would produce only a small part of the needed water.

"Under the most ideal weather conditions," Dr. Woodley noted before the experiment began, "we will be able to help alleviate the water shortage. It is unlikely, however, that our efforts alone will break the drought. A good naturally rainy period will be required to fill the reservoirs."

During the two-month period, aircraft of NOAA's Research Flight Facility were able to seed on 14 days. One RFF DC–6 flew 72 hours of seeding missions; the B–57, used as backup seeder, flew 17 hours. More than 2000 silver iodide flares were used.

The Central and Southern Flood Control District installed 147 recording rain gages in the target area, and the State of Florida purchased 1000 silver iodide flares.

Early analysis of the results showed that on 11 of the 14 seeding days considerable cloud growth, sometimes accompanied by natural cloud growth, occurred in the seeded areas. On 10 of the days, seeded clouds merged and produced heavy rainfall in the parched Everglades. On April 26 and May 22, substantial rainfall also occurred in the Miami area. A detailed evaluation of the results for the entire period is under way.

At the request of the Flood Control District, the experiment is being continued during the regularly scheduled tropical cumulus seeding study from June 1 through mid-July in South Florida. A continuation of the successful 1968 and 1970 experiments, this program is a randomized, fully radar monitored, scientific experiment under the joint direction of Drs. Simpson and Woodley.

NOAA Emblem Selected

The emblem selected for the National Oceanic and Atmospheric Administration symbolizes NOAA's worldwide role in the environmental sciences and the role of these sciences in defining and determining ecological relationships, promoting better use of our national resources, and providing a better understanding and predictability of the global phenomena.

It will be used, when appropriate, to identify installations, offices, facilities, activities, publications, equipment, and by NOAA employees on private vehicles for parking purposes. The emblem is available to employees in decal form, and is stocked by the NOAA Central Logistics Supply Center, Federal Building 9, 601 Hardesty Street, Kansas City, Mo. 64124, where requests from offices should be addressed.

Secretary M. H. Stans Ends U.S. Whaling

Secretary of Commerce Maurice H. Stans has moved to protect the remaining species of whales still in existence by ending commercial whaling from the United States, with a final termination date of Dec. 31, 1971.

This action marks the final chapter in an industry which first originated along the New England coast in the early colonial days of our country, and reached its highest activity during the first half of the 19th century.

The Secretary directed the National Marine Fisheries Service to publish a proposal in the Federal Register terminating the licensing of commercial hunting of whales listed as endangered species. The list contains eight species, including the finback, sei and sperm whales, which are the only species now sought by U. S. commercial whalers, as well as the rarer bowhead, blue, humpback, right and grey whales. The whales had been placed on the endangered species list by the Department of Interior last December, and this action by the Secretary carries out the intent of that action.

Wallace Becomes Associate Administrator; Aron, Clotworthy Head New Staff Offices

Three newly created NOAA posts have been filled by recent appointments—David H. Wallace as Associate Administrator for Ocean Resource Management, Dr. William Aron as Director of the Office of Ecology and Environmental Conservation, and John H. Clotworthy to head the Office of Congressional and Legislative Affairs.

As Associate Administrator for Ocean Resource Management, Mr. Wallace is responsible for developing NOAA policy and guiding efforts in assessment, conservation, development, and management of ocean resources.

DAVID H. WALLACE

Mr. Wallace had served since 1969 as Director of the Division of Marine and Coastal Resources in New York State's Department of Environmental Conservation. For the seven preceding years, he was Deputy Director of Fish and Game for the Marine Region, New York State Conservation Department.

He is a graduate of Washington College and holds a master's degree from the University of Maryland. From 1936 to 1940, he was engaged in fisheries research at the Chesapeake Biological Laboratory and joined the Maryland Department of Tidewater Fisheries as its Administrator in 1941. Mr. Wallace has been active in numerous fisheries efforts at the Federal level, serving as a member of the Fisheries Advisory Committee to the Department of State, of the Fish and Wildlife Advisory Committee to the Secretary of the Interior, and of several U.S. missions to negotiate Middle Atlantic Fisheries Agreements.

Dr. Aron had been associated with the Smithsonian Institution since 1967, as Deputy Director and later Director of the Oceanography and Limnology Department. He headed the biological oceanography program for AC Electronics Defense Research Laboratories from 1961 to 1967, and was an assistant research professor in the oceanography department at the University of Washington from 1956 to 1961.

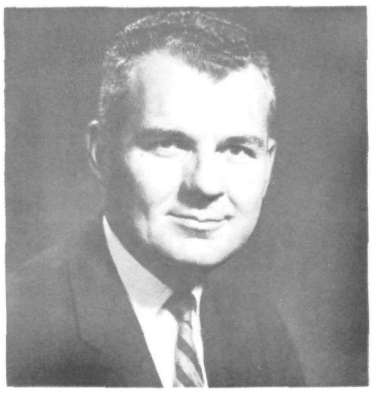
DR. WILLIAM ARON

He holds a bachelor of science degree from Brooklyn College, and earned his master's and doctorate at the University of Washington.

As Director of NOAA's Office of Ecology and Environmental Conservation, Dr. Aron will be responsible for ensuring full consideration of environmental protection matters.

Before his appointment as Director of the Office of Congressional and Legislative Affairs, Mr. Clotworthy was president and chairman of Oceans General, Inc., a Miami, Fla., engineering and manufacturing firm. He has been active in a broad range of marine and oceanographic affairs, serving on the Man in the Sea Panel of the National Academy of Engineering Committee on Oceanography, on the U.S. Chamber of Commerce Committee on Natural Resources, and as a founding member of the Marine Technology Society.

A 1946 graduate of the University of Virginia with a degree in electrical engineering, Mr. Clotworthy later studied at the Harvard Graduate School of Business Administration and the University of Maryland Law School.



JOHN H. CLOTWORTHY

He has been manager of the Westinghouse Electric Corporation's Baltimore division, and chairman of the University of Miami's Division of Engineering.

The Office of Congressional and Legislative Affairs will coordinate NOAA's congressional activities, serve as the focus for development of legislative programs, and advise on legislative matters affecting NOAA's programs and activities.

NOAA Commissioned Officers Named To Top Spots at Lake Survey Center

Captain Robert E. Williams of the NOAA commissioned corps has been named Director of the National Ocean Survey's Lake Survey Center, with Lt. Cdr. Sigmund R. Petersen serving as Deputy Director.

A graduate in civil engineering of the University of Wyoming, Capt. Williams has served aboard four Seattle-based NOAA ships and at various posts in the United States and abroad, including Portland, Oreg.; Washington, D.C.; Monrovia, Liberia; and Seattle, Wash. Before his Lake Survey appointment, he was Chief of Operations at the Pacific Marine Center.

Lt. Cdr. Petersen joined the Coast and Geodetic Survey in 1961, after graduation from Washington State University. He has served aboard the NOAA Ships PATHFINDER and McArthur, with hydrographic field parties, as recruiting officer in Kansas City, with a special projects group in hydrography and oceanography, and with the 1969 Barbados Oceanographic and Meteorological Experiment.

Harbor Survey Supports Effort For Clean Water

A detailed study of the dynamics of water circulation in Boston Harbor and Massachusetts Bay is being conducted by the National Ocean Survey.

Part of a larger program of similar studies in coastal and estuarine waters, the survey will provide data needed by pollution control authorities to maintain and preserve the quality of the marine environment. The up-to-date information on current speed and direction in the Boston Harbor area also will contribute to the safety of navigation.

The two-year investigation is being carried out from the NOAA Ship FERREL, commanded by Lt. Cdr. Karl W. Kieninger, Jr.

The FERREL's primary means of observing currents is the TICUS (*TI*dal *CU*rrent *S*urvey) System, which is being used extensively in the program. The system uses current meters suspended from buoys at preselected stations throughout the Boston Harbor area. Observations of the speed and direction of the current at various depths at each station are recorded for reduction and study by the National Ocean Survey at Rockville, Md.

Travel Forecasts Are Given Test In the Midwest

The National Weather Service is conducting a test program in eight midwestern states of a system of experimental weather forecasts designed specifically for travelers.

For some time, officials of the Weather Service have felt that there is a demand for abbreviated forecasts for major U.S. cities that will give long-distance travelers an idea of what to expect when they reach their destinations.

The eight states to receive the service in the test program are Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Missouri, and Wisconsin. They will get forecasts for 65 cities, distributed nationwide. Initial release will be to major Midwest newspapers and wire-service offices. Media managers and editors will be asked for reader response to the forecasts.

When the new system has been evaluated and refined, it is planned to issue the travelers' forecasts nationally. A daily summary will be compiled by computer at the NWS National Meteorological Center. Cities included in the forecasts will be major transportation centers or state capitals.

FPC Demonstration Plant Begins Operation

The National Marine Fisheries Service Fish Protein Concentrate (FPC) Experiment and Demonstration Plant at Aberdeen, Wash., was dedicated April 17.

Senator Warren G. Magnuson and Rep. Julia Butler Hansen were guests of honor at the ceremonies, and were introduced by Howard W. Pollock, NOAA Deputy Administrator.

In her keynote address, Representative Hansen, a long-time supporter of FPC, pointed out the benefits to be reaped from improved nutrition through the wide use of high-quality protein products.

The National Marine Fisheries Service has pioneered the development of FPC, a light tan powder which contains nearly 80 percent high-quality protein and can be used as a food additive.

The purpose of the plant is to demonstrate the feasibility of the solvent extraction process developed by NMFS, and to obtain design, engineering, economic information to serve as a basis for construction of commercial plants by private industry. The plant will not produce FPC for commercial purposes.

The facility was designed and built by Ocean Harvesters, Inc., of Los Angeles, and will be operated by that company under contract. Land for the plant, near the confluence of the Chehalis and Wishkah rivers, was donated by the Port of Grays Harbor, Aberdeen, Wash.

(From left) Howard W. Pollock, NOAA Deputy Administrator; Senator W.G. Magnuson; and Representative Julia B. Hansen cut ribbons at dedication of FPC plant.

NOAA Coastal Flooding Studies To Aid HUD Insurance Program

The Federal Insurance Administration of the Department of Housing and Urban Development has contracted with NOAA for flooding studies of 17 selected coastal communities in Florida and two in South Carolina, to assist in its responsibilities for carrying out the provisions of the Flood Insurance Act of 1968.

The Act of 1968 makes flood insurance available to the private home owner for the first time, based on the flood risk for his residence. The Act also requires that communities use good planning in their flood plans. Both of these purposes will be served by the studies performed by NOAA.

The principal organizationa units involved in the program are the National Ocean Survey's Oceanography and Photogrammetry Divisions and the Water Management Information Division and the Techniques Development Laboratory of the National Weather Service. The derivation of storm surge-time relations is done by the NWS units using as input its climatology data and tidal observations processed by the Oceanography Division. The actual demarcation of the flood zones and the final compilation of flood insurance maps are done by field and office units of the Photogrammetry Division.

More VHF Stations To Open This Year

The National Weather Service is adding 15 new sites to its network of continuous-transmission weather radio stations.

Before the end of the year, stations will be broadcasting from locations in or near Atlanta, Ga.; West Palm Beach, Fla.; Sacramento and San Diego, Calif.; Minneapolis, Minn.; Milwaukee, Wisc.; Wichita, Kans.; Detroit, Mich.; Fort Worth and Dallas, Tex.; Erie, Pa.; Wilmington, N.C.; Mobile, Ala.; Buffalo, N.Y.; and Anchorage, Alaska.

The 15 new stations will bring to 43 the number of VHF-FM transmitters in the Weather Service's nationwide network.

EDS To Manage U.S. IDOE Data

The National Science Foundation has designated the Environmental Data Service as the lead agency for data management and information services for all International Decade of Ocean Exploration (IDOE) projects funded by NSF.

Facilities and personnel of three EDS data centers—the National Oceanographic Data Center, the National Geophysical Data Center, and the National Climatic Center—will be involved in storage, formatting, and disseminating IDOE geophysical, oceanographic, and meteorological data. NODC will serve as the focal point for inventorying the data and providing information about IDOE programs.

In addition, the EDS centers will review all IDOE proposals to ensure that adequate attention is paid to data processing and documentation, and will arrange the scheduling for submission of inventories and data to the proper repositories.

NODC To Teach IOC Trainees

The National Oceanographic Data Center has been selected as the lead agency in a new training program established under the auspices of the Intergovernmental Oceanographic Commission (IOC) of UNESCO.

The project has been set up to train qualified personnel from developing countries of Asia, Latin America, and Africa to strengthen their ability to obtain, process, and effectively use marine data.

Candidates for the course—to be chosen by the Secretariat of IOC—will be individuals concerned with marine science, technology, and related subjects in their countries, who have adequate scientific or technical backgrounds and facility in the English language.

Three training courses, each for about seven trainees, will be conducted by NODC in the United States from June 1971 to December 1972.

Lake Survey Tests Buoy For Field Year

Scientists of the Lake Survey Center are testing the instrumentation on a prototype buoy to be used in data collection for the International Field Year for the Great Lakes (IFYGL). Dr. Thomas H. Saylor is the scientist in charge of the project.

The buoy was designed and fabricated by Texas Instruments, Inc., and is equipped with meteorological instruments placed at a level of three meters above the water surface. Included in the installation are sensors for the measurement of wind speed and direction, air temperature, dew point, and barometric pressure. There are also thermistors spaced along the mooring cable to measure water temperatures at various depths, as well as current meters placed at four levels.

The environmental measurements taken from the buoy platform are transmitted to a shore station by radio telemetry, and by telephone lines to computer facilities in Detroit for real-time data recording and analysis.

Marine Services Are Coordinated In Federal Plan

For purposes of MAREP, the marine environment encompasses the deep ocean, the coastal zone, and the Great Lakes. MAREP includes analyzing and forecasting the physical, chemical, biological, and hydrodynamic states of the ocean and the overlying atmosphere, and their interaction.

Programs of nine Federal agencies contribute to MAREP services. Total costs are estimated at $125.4 million in FY 1971 and $145.2 million in FY 1972, including operations, service improvement, and relevant research.

A comprehensive Federal program for Marine Environmental Prediction services was published recently.

The **Federal Plan for Marine Environmental Prediction,** Fiscal Year 1972, was prepared by the Federal Coordinator for MAREP with the advice and assistance of the Interagency Committee for Marine Environmental Prediction.

Purposes of the program are to integrate all present Federal marine environmental monitoring systems, to assess and improve these systems, and to provide better prediction and warning services to people engaged in activities within the marine environment.

Sea Grant Awards Cover Wide Range Of Projects

Salmon culture experiments by the National Marine Fisheries Service have proved so successful that a private firm, with the aid of a $100,000 NOAA Sea Grant, is adapting the system for possible commercial production.

Ocean Systems, Inc., will attempt to demonstrate the feasibility of a commercial-sized pilot operation to raise pan-size salmon from egg to market size in enclosures in Puget Sound. The NMFS Biological Laboratory in Seattle will provide technical advisory services on the grant.

Three recent Sea Grants were for projects in management of coastal and estuarine resources: $249,600 to the Virginia Institute of Marine Science; $216,700 to the University of Georgia (Athens); and $139,200 to the Nassau-Suffolk (New York) Regional Planning Board.

In the first Sea Grant project in Oklahoma, the University of Oklahoma was awarded $161,800 for a program to obtain antibacterial compounds from coral. Stevens Institute of Technology is also conducting research in marine pharmacology under a $203,000 grant.

Other Sea Grants were awarded to:

Caribbean Research Institute, College of the Virgin Islands, $47,500 for investigation of ciguatera poisoning;

Lehigh University, $180,800 for continuing studies of probes used from submersibles;

Lamont-Doherty Geological Observatory, $50,000 to continue an artificial upwelling project in the Virgin Islands;

University of New Hampshire, $18,300 for a project to give undergraduate engineering students experience in components and systems used in ocean programs;

University of South Florida, $40,000 for ecological and culture studies of a common Florida seaweed that contains carrageenan, a little-known but important element in many processed foods;

University of California at Santa Barbara, $32,500 for first-year feasibility studies of an ocean-bottom scanning system for exploration and underwater search;

Medical College of Wisconsin, $26,500 for a systematic study of a chemical commonly used in the upper Great Lakes to control sea lampreys.

NOAA Ocean Survey Vessels Complete Major Scientific Expeditions

NOAA ships and scientists have been pursuing clues to the history of the earth's crust beneath the Atlantic and Pacific oceans.

From April through June, the NOAA Ship DISCOVER continued the Trans-Atlantic Geotraverse (TAG) begun last year. The investigation was centered on the 250-mile-wide, 3500-mile-long corridor between Cape Hatteras, N.C., and Cap Blanc in northwest Africa. This corridor is believed by many scientists to be the path the North American and African continents took when they split and began drifting apart some 200 million years ago.

Conducted by the Atlantic Oceanographic and Meteorological Laboratories and the National Ocean Survey, the project is part of the United States' contribution to the International Decade of Ocean Exploration which is funded by the National Science Foundation. Dr. Peter Rona was chief scientist for the expedition.

Advanced electronic equipment probed the bottom and subbottom along the corridor to determine the structure and sample the rocks which form the ocean bottom. Also investigated were reported domes within the corridor off northwest Africa, structures resembling the oil-producing salt domes of the gulf coast of the United States. Located in water 15 to 20 thousand feet deep, these are the first such domes to be reported on the deep ocean bottom. Previously, it had been believed that the occurrence of salt domes was limited to the continental shelves.

The NOAA Ship OCEANOGRAPHER completed a three-month study in the northeast Pacific, in search of new evidence that the sea floor is constantly moving and carrying with it giant segments of the earth's crust. Chief scientists for the expedition were Frederic Naugler and John Wageman of the Pacific Oceanographic Laboratories.

Four separate areas of the Pacific were studied during the 22,000-mile voyage. Evidence of sea floor spreading was sought between the Murray and Mendocino fracture zones, in the Chinook Trough, the northern Gulf of Alaska, and in a fracture zone just west of the Queen Charlotte Islands off the coast of British Columbia.

The scientists made detailed examinations of the subbottom, using seismic reflection instruments which electronically probe beneath the sediment and muck on the ocean bottom.

On the last leg, several days were spent in an investigation of undersea mountains about 140 miles west of the Queen Charlotte Islands. Dredges were dropped to the tops of the seamounts to determine their composition, and seismic reflection profiles were made of the one-mile-high mountains to determine their general structure.

In April and May, the SURVEYOR made a 6800-mile trip from American Samoa to South America, to gather data on the geophysical characteristics of the oceanic crust between the Tonga Trench and the East Pacific Rise. Barrett H. Erickson of the Pacific Oceanographic Laboratories was chief scientist.

NOIC Evaluating Timed Mechanism For Buoy Release

Field tests of a timed device used to release buoys have been conducted at sea in the Tongue of the Ocean near Nassau by Charles Dinkel and Mykola Stawnychy of the National Oceanographic Instrumentation Center's Reliability Division. The tests were supported by personnel of the National Ocean Survey.

The reliability and performance data acquired during the test is being evaluated, and several reports based on this data are being written for publication.

The testing of the release devices was the second phase of a broad program designed to establish the reliability of release mechanisms in the following classes: corrosive, mechanical, and acoustic. A comparison study simulating the salinity, temperature and depth of the sea at the test site is being planned and will be conducted in NOIC's Environmental Facility.

Data Buoy Project Gives Contracts For Systems To Be Tested in Gulf

A network of environmental data buoys is scheduled for placement in the Gulf of Mexico in April 1972, for tests that will continue through 1973.

Contracts for platforms and sensors for the engineering experimental phase of the National Data Buoy Project were awarded in April. The purpose of this phase is to evaluate buoy systems and improved oceanographic and meteorological sensors, as well as to gain experience in operating a data buoy system and in handling the data from it.

Testing and evaluation in the Gulf of Mexico will be coordinated by the Project's staff at the Mississippi Test Facility near Bay St. Louis, Mississippi. Support will be provided by the U.S. Coast Guard, which has announced the shifting of a vessel from the west coast to Gulfport, Mississippi, for this purpose.

Electro Dynamic Division of General Dynamics was selected to build the ocean platform systems, consisting of buoy hull, moorings, power system, data processing system, and communications system. The buoy has a discus-shaped hull and can withstand hurricane conditions of 150-knot winds, 60-foot waves, and 10-knot currents. Each buoy weighs about 100 tons when on station and is capable of carrying more than 100 sensors on the hull, along the mast, and on the mooring line.

The company will also act as system integration contractor and will modify the Buoy Project's data receiving station, located at the U.S. Coast Guard's Radio Station in Miami, to accept data from the system. From Miami, the data will be transmitted to the National Meteorological Center and to the National Data Buoy Project's office at the Mississippi Test Facility.

Environmental sensors will be developed and tested by Westinghouse Electric Corporation's Ocean Research and Engineering Center. Sensors will gather ocean and atmospheric data, including wind speed and direction, rainfall, air temperature and pressure, dew point, water temperature, current speed and direction, conductivity, and sound speed.

KNUDSEN HEADS NWS CENTRAL REGION

Charles G. Knudsen, Deputy Director and Chief of Operations at the National Weather Service's Eastern Region headquarters in New York since 1964, has been appointed Director of the Central Region.

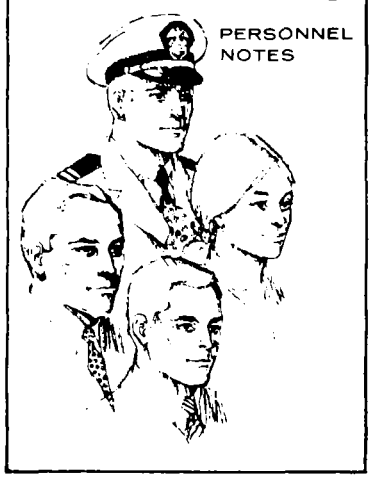
He succeeded Roy L. Fox, who retired May 24.

As Director of the Central Region, Mr. Knudsen will supervise the operations of Weather Service facilities in 14 states—Michigan, Indiana, Kentucky, Wisconsin, Illinois, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas, Wyoming, and Colorado.

Mr. Knudsen has had 30 years' experience in meteorology. Before his assignment at Eastern Region headquarters, he served for eight years in key posts in New York.

He holds a bachelor's degree from St. John's University, a master's degree from Columbia, and has done graduate work in meteorology at New York University. In 1968, he was awarded a Commerce Department silver medal for significant improvements in forecasts and warnings.

all in the family



Cdr. Robert W. Franklin, NOAA Corps officer, has been appointed Director of the NOS Anchorage (Alaska) Field Office, succeeding Capt. G. E. Haraden, who has been named Operations Officer at the Survey's Pacific Marine Center in Seattle. Cdr. Franklin, former Executive Officer of the NOAA Ship RESEARCHER, joined the commissioned corps in 1957.

Louis J. Ronsivalli has been appointed Director of the National Marine Fisheries Service's Fishery Products Technology Laboratory in Gloucester, Mass. Prior to joining the Federal service in 1963 as leader of the Radiation Program at the Gloucester Technological Laboratory, Mr. Ronsivalli was a Research Associate in the Department of Nutrition and Food Science at the Massachusetts Institute of Technology.

David W. Holmes has been appointed Chief of the NWS Data Acquisition Division's Sounding Systems Branch. Mr. Holmes serves as a consultant to national and international agencies in the fields of observations and instruments, particularly surveillance radar and upper-air measurements. He began his career with the NWS in 1950.

Dr. Herbert E. Bruce has been named Director of the National Marine Fisheries Service's Biological Laboratory at Woods Hole, Mass. Dr. Bruce was formerly Assistant Director of the NMFS Biological Laboratory at Auke Bay, Alaska. He joined the Federal fisheries service in 1961. At the Woods Hole Laboratory, Dr. Bruce heads the nation's oldest Federal marine fishery facility, where research is centered on the important off-shore fish that support New England's commercial fisheries.

Captain Dewey G. Rushford has been appointed to head NOS's Ship Facilities Group in Rockville, Md. The Ship Facilities Group is engaged primarily in the development of basic concepts for new ships engaged in oceanographic investigations and hydrographic surveys. Capt. Rushford has been chief of the NOS New York Field Office since August 1968.

Dr. Robert S. Dietz, a marine geologist at ERL's Atlantic Oceanographic and Meteorological Laboratories in Miami, has received the Walter H. Bucher Medal given by the American Geophysical Union for original contributions to basic knowledge of the earth's crust. Dr. Dietz was cited for pioneer work in many areas of marine geology, including his discovery of the existence of fracture zones, his investigation and naming of the process of sea floor spreading, and his studies of continental margins and continental drift.

Philip M. Cohen is the new Chief of the NOS Marine Geophysics Group. Mr. Cohen, a geodesist, has been with the Federal government for 20 years.

D. A. Carlson, Raymond J. Sauer, and **Gordon D. Shadoan** have been appointed key assistants in the Northwest Administrative Office in Seattle. Mr. Carlson, who is Chief of the Budget, Finance, and Management Division, had been Budget and Fiscal Officer for the NMFS Regional Office in Seattle for the past ten years. Before his new assignment as Chief, Administrative Operations Division, Mr. Sauer was Chief of the Procurement and General Services Division at the NMFS Seattle Regional Office. Mr. Shadoan, who has been named Chief of the Personnel Division, was Chief of the Operations Branch in the NOAA headquarters Personnel Division before his new assignment.

Leslie W. Scattergood, former Chief of the U.S. Fish and Wildlife Service's Reports Branch, is now Chief of the Scientific Information and Documentation Division's Editorial Branch. Mr. Scattergood has spent most of his 33 years of Federal service with the U.S. Fish and Wildlife Service of the Department of Interior.

Harold A. Corzine has joined the Scientific Information and Documentation Division as the new editor of the *Monthly Weather Review.* Prior to his recent appointment, he served with the Naval Air Command's Research and Development Management Office. He was the project officer of the Navy program in weather modification.

Dr. Harry P. Foltz, Chief of the NWS Weather Analysis and Prediction Division, has been elected chairman of the Washington, D.C., Chapter of the American Meteorological Society, succeeding Cdr. K. W. Ruggles, Officer in Charge of Navy Project FAMOS (Fleet Applications of Meteorological Observations from Satellites). Other officers elected for the year 1971-72 in the local chapter include: Earl Estelle, Deputy Chief, Analysis and Forecasting Division, NWS — corresponding secretary; Maurice E. Pautz, Weather Analysis and Prediction Division, NWS — treasurer; and Dr. Duane Cooley, Chief, Technical Procedures Branch, NWS—member at large.

Edwin G. Provost has been named the meteorologist in charge of the National Weather Service Office at Topeka, Kans., replacing Richard A. Garrett who retired. Mr. Provost is the fourth MIC at the Topeka office since its establishment in 1887. He has been one of the forecasters at the National Severe Storms Forecast Center at Kansas City for the past 19 years.

Dr. Thomas S. Austin, Director, EDS, has been appointed by the National Academy of Sciences as NOAA representative for 1971-73 to the International Federation for Documentation (FID). The organization is an international, non-governmental organization, which seeks to promote the development of documentation and information activities through international cooperation.

Cecil M. Palmer, former service operations dissemination meteorologist, Southern Region headquarters, Fort Worth, has become meteorologist in charge of the Brownsville, Tex., Weather Service Office. Mr. Palmer entered the weather service in 1947 after two years in the U.S. Navy.

Bernard D. Zetler, senior research oceanographer at ERL's Atlantic Oceanographic and Meteorological Laboratories in Miami, has been named to the Committee on Tides and Mean Sea Level of the International Association of the Physical Sciences of the Ocean.

John F. Miller, former Chief of the Water Management Information Division's Special Studies Branch, Office of Hydrology, NWS, is now Chief of the Water Management Information Division.

Lt. Carroll Dale North, Jr., NOAA Corps officer, has assumed command of the Norfolk-based, high-speed boat, Launch 1257.

Cedric B. Samuel, a cartographer in NOS's Marine Chart Division, was re-elected to a third two-year term as Councilman and a second consecutive term as President of the Council in the Mount Rainier, Md., municipal election.

Harold E. Lowman has been named the new official in charge of the NWS office at Concordia, Kans. He replaces Lee Stinson, who recently moved to the official in charge post at Dodge City, Kans. Mr. Lowman entered the National Weather Service at Goodland, Kans., in 1946. He came to Concordia from Annette Island, Alaska, where he had been principal assistant.

Lt. Lowell J. Genzlinger recently received top honors in a class of 30 pilots graduated from the Army Flight Class, Fort Rucker, Ala. Following graduation, Lt. Genzlinger was assigned to a photogrammetric flight mission as a pilot.

Clarence E. Vicroy, former Chief of the Operations Branch of the NWS Office of Hydrology, is now the hydrologist in charge at the River Forecast Center in Slidell, La. Mr. Vicroy entered the weather service at Fort Worth in 1964, following retirement from the U.S. Air Force.

Joseph A. Strahl, of the National Weather Service's Office of Hydrology, is now Chief of the Hydrologic Services Division's Operations Branch. Mr. Strahl has served in the Operations Branch for the past three years. Before coming to Washington, D.C., he was assigned to the Sacramento, Calif., River Forecast Center.

Charles M. Purdy, formerly an electronic engineer in ERL's Aeronomy Laboratory, Boulder, Colo., has been named Chief of ERL's Administrative and Management Services.

Gregory S. Richter, meteorologist in the National Weather Service's Public Weather Branch, has been honored by the National Science Foundation's U.S. Board on Geographic Names. A geographical feature located in the Saunders Coast of Marie Byrd Land, Antarctica, has been named Richter Glacier.

Richard C. Sawyer is the new official in charge of the Weather Service Office at Johnston Island in the Pacific. Mr. Sawyer joined the weather service in 1955.

Joseph C. Myers is now meteorologist in charge of the National Weather Service's Meteorological Observatory at Garden City, Kans., replacing Jack Hughes, who transferred to a quality control officer position at Great Falls, Mont.

Dale W. Rice, wildlife biologist from the NMFS Marine Mammal Biological Laboratory in Seattle, has transferred to the scientific staff at the NMFS Fishery-Oceanography Center in La Jolla, Calif.

Dr. Robert S. Cohen of ERL's Aeronomy Laboratory has been appointed to the Committee on Environmental Quality of the American Geophysical Union.

Beaufort Research Center Studies Charleston Harbor Dredging Effects

The effects of dredged harbor sediments on the biology of Charleston Harbor, S.C., is being studied under an Army Corps of Engineers contract awarded the National Marine Fisheries Service Center for Estuarine and Menhaden Research at Beaufort, N.C., and the Belle W. Baruch Coastal Research Institute of the University of South Carolina.

Charleston Harbor has had various types of pollution, ranging from municipal to industrial and agricultural wastes for many years. These wastes may include concentrations of heavy metals, pesticides, oil, and other organic and inorganic salts that could affect marine and estuarine organisms. Large amounts of silt and sediment are dredged from the harbor each year to maintain ship channels. Present plans call for deepening the channels to permit large ships to enter the harbor.

The cooperative study is an effort to determine how stirring up sediment and its associated toxic materials will affect certain planktonic organisms and the young of certain fish. These were selected for the initial study because of their fundamental importance to the survival of a disturbed ecosystem, and because these stages are generally regarded as the most sensitive to environmental disruption.

Data from the study will assist in evaluating proposed environmental alteration of the waters in Charleston and neighboring localities. The study is under the direction of Donald Hoss, fishery research biologist at the Beaufort laboratory, and Dr. F. John Vernberg of Baruch Institute.

It's One Hundred for Galveston

The National Weather Service Office at Galveston, Texas, completed its first century of operation on April 19, 1971, and marked the occasion with three days of special centennial activities. The highlight was the dedication of a Texas Historical Marker honoring the service of the weather office in Galveston. Karl R. Johannessen, Weather Service Associate Director (Meteorological Operations), spoke at the dedication of the historical marker. Southern Region Director L. R. Mahar and Galveston meteorologist in charge Davis Benton joined Mr. Johannessen in unveiling the marker.

Unveiling the historical marker, from left, Galveston MIC Davis Benton, Mrs. Mary Moody Northern, Karl R. Johannessen, and Lawrence R. Mahar.

Dams Can Cause Earthquakes, NOS Geophysicist Concludes

Based on a study of seismic data recorded at dams in the United States, Wendell Mickey, a National Ocean Survey geophysicist, has concluded that where dams are built over or near active faults, the weight of the water in the reservoirs causes an increase in earthquakes.

Earthquakes have occurred around dams, and other manmade bodies of water from the east to the west coast and from Canada to the Gulf of Mexico. A study of the records of the more than 10,000 earthquakes which have occurred at the Hoover Dam makes it clear, he said, that they were related to the increasing weight of water, since no earthquakes had been reported in the 15-years before the dam was built.

Significantly, Mickey pointed out, after several smaller dams were built above Hoover Dam in 1962 to regulate the flow of water, the water level fluctuated less and there was a 50 percent decrease in the number of earthquakes.

Over the years there have been several reported instances of earthquakes allegedly related to water load.

In 1955, nearly 200 shocks occurred in eastern Washington, apparently caused by shifting subterranean rock due to the weight of irrigation water.

In 1961, at Rocky Reach Dam and Entiat Lake in Washington, several shocks were felt after impounding of water in newly created Lake Entiat.

In 1944, at Shasta Dam, Calif., several shocks were believed to have been due to the settling of the bottom of Shasta Lake under pressure of stored water.

In 1969-70, at Flathead Lake and Kerr Dam, Montana, more than 200 earthquakes were felt.

The NOAA scientist recommended that the seismicity of an area be determined before a dam is constructed and that no dam be built over or within the disturbed zone of an active fault unless adequate precautions are taken.

Mickey said further study of the effect of manmade lakes and reservoirs on earthquakes is needed before definite conclusions can be reached. He stressed the need for such studies, pointing out that the demand for water reservoirs will increase, with approximately 125 dams more than 50 feet high being built each year in the United States.

Report Issued on California Quake

A report describing the nature and effects of the earthquake that struck the San Fernando Valley, California, on the morning of February 9, 1971, has been published jointly by the U. S. Geological Survey, Department of the Interior, and NOAA.

The geographic setting of the San Fernando earthquake, its damaging effects, and many of the geologic features of the ground movement that generated the quake, are described in the 254-page document, illustrated with numerous photos, maps, and graphs.

In a series of articles prepared in cooperation with several other Governmental agencies, universities, and private engineering consulting groups, the report summarized findings from teams of scientists and engineers who were dispatched quickly to the scene to begin a study of the quake and its effects.

USGS and NOAA officials said that "such prompt response was vital because even temporary repairs would have obliterated much of the field evidence that earth scientists use to determine the nature and behavior of the earthquakes."

The report, "The San Fernando Earthquake of February 9, 1971—A Preliminary Report," may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 for $2.25 per copy.

Federal Agencies Plan for Future U.S. Earthquakes

The National Ocean Survey, in collaboration with the Office of Emergency Preparedness, is undertaking an eight-month study of the effects of earthquakes. Data from the Feb. 9 Los Angeles earthquake will be used as background for the study.

To aid in planning for earthquake disasters, the study will include estimates of total earthquake losses that could be experienced in the event of a large quake. Damages will be estimated for earthquakes in magnitudes of 8.3, 7.5, and 6.5 on the Richter scale. These will include estimates of damage to various types of structures, public utilities, transportation, and communications systems. Major geologic hazards and probable casualties at each degree of severity also will be included.

The study will provide the Office of Emergency Preparedness with a better data base for preparedness planning assignments to federal agencies, and for providing guidance to state and local agencies preparing earthquake disaster plans for California and other states.

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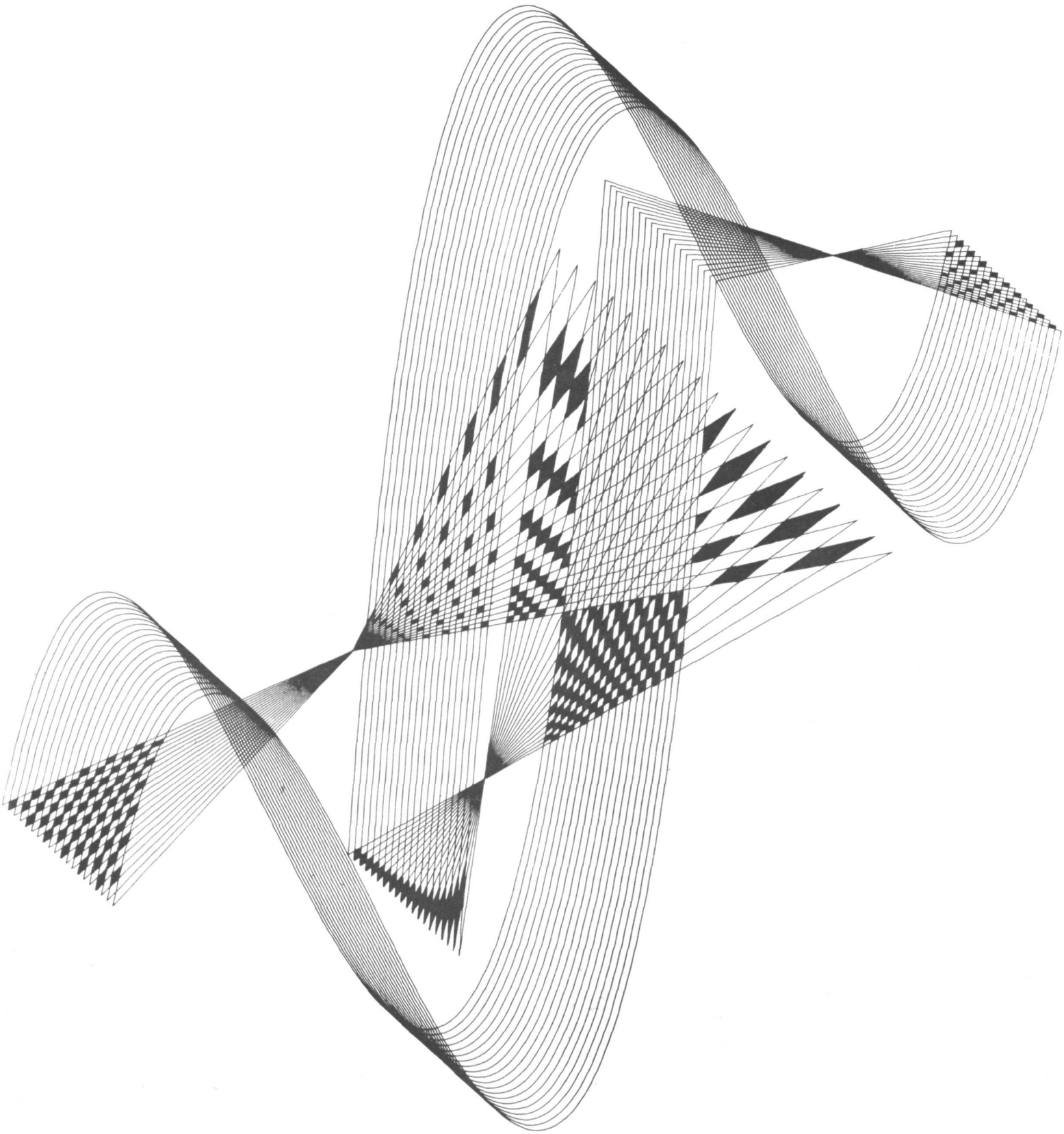
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