VOLUME 3 NUMBER 2 APRIL 1973

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National Oceanic and Atmospheric Administration

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Cover

As the 1973 tornado season opened, the National Weather Service launched its annual SKYWARN campaign to save lives through tornado preparedness. On the back cover, the inside stairway of the Atlantic Oceanographic and Meteorological Laboratories' new building forms a striking pattern.

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U.S. DEPARTMENT OF COMMERCE
Frederick B. Dent, Secretary

National Oceanic and Atmospheric Administration

Dr. Robert M. White, Administrator
Howard W. Pollock, Deputy Administrator
Dr. John W. Townsend, Jr.,
Associate Administrator

A Message From the Administrator

ROBERT M. WHITE

In these times of stringent budgets and some program curtailment, it is very easy to lose sight of the fact that by far the great bulk of all that we do in NOAA will continue and, in many cases, will expand.

It is important that all of us realize that the services we render and the research we conduct are among the most essential and effective in the Federal Government.

Among the enormous and difficult tasks that continue to confront us are these:

—To provide adequate environmental forecasts and warnings, on which the lives, safety, and welfare of our people, our commerce, and our industry depend.

—To protect our national fisheries resources and develop system of fisheries management that will enable this and future generations to enjoy the bounty of the sea.

—To render services and assistance to both our commercial fishing industry and the recreational fishing interests, so that they can thrive and grow, providing employment to many and enjoyment to millions.

—To understand the nature of man's pollution of the oceans and the atmosphere, so that those responsible for making decisions about the effective use of the oceans and atmosphere can do so in the light of the best scientific and technical knowledge available. The recent results of the MARMAP surveys on the distribution of oil, tar and plastic substances throughout our oceans are a case in point.

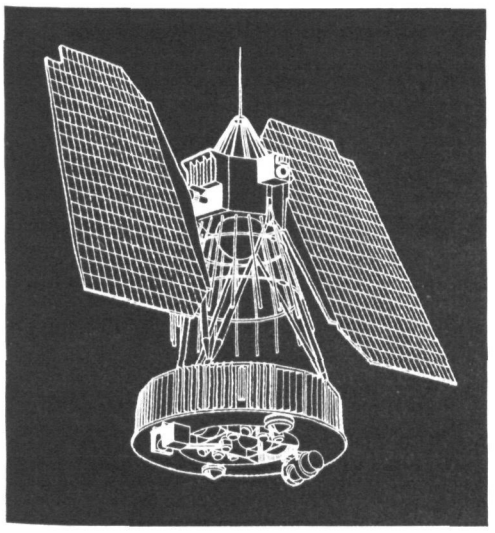
—To carry out for new responsibilities for building a system to protect marine mammals from human depredation and unwarranted commercial exploitation.

—To provide better and more accurate surveys and charts of the oceans and coastal zones, supporting the needs of deep-draft vessels and the national requirement for planned management of the coastal zones.

—To continue to examine the feasibility of modifying the environment in a beneficial way.

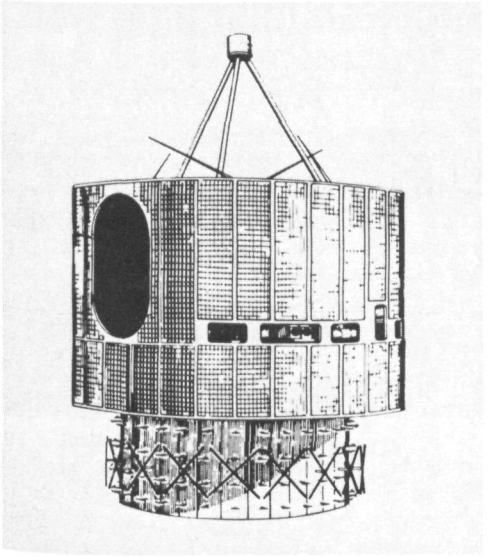
Each of these tasks poses a great challenge for, in each, much remains to be accomplished. The privilege of participating in progress toward these goals should be, for all of us, a source of pride.

Robert M. White



SPACE WATCH ON THE GLOBAL SEA

Two Satellite Service groups use data from space to expand man's knowledge of the earth's waters.



BY ANN K. COOK

Soon after the launch in 1960 of the first weather satellite, TIROS I, scientists found that large areas of ice on oceans and lakes and of snow on the ground could be identified in pictures returned from the spacecraft.

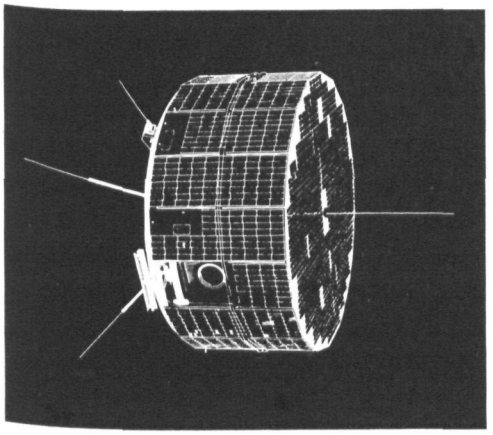
Photographs of the same region, taken on successive days, showed cloud systems constantly moving and changing. But ice and snow appeared again and again in the same places, changing very slowly.

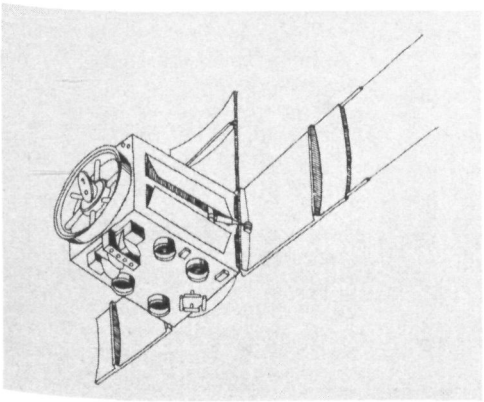
This discovery, that the white of ice and snow could be distinguished from the white of clouds, led to the first applications of satellite data in the fields of oceanography and hydrology.

When a satellite looks at the weather, it also sees the earth's waters. And as space technology has advanced over the past 13 years, through steadily improving camera systems, infrared imagers, geostationary satellites, radiometer soundings of temperature, and microwave systems, the value of satellite data to oceanographic and hydrologic operations and research has increased.

Today, satellite-derived information on sea-surface temperatures, sea and lake ice, and major ocean currents is assisting the operations of shipping and other marine interests. Snow over vast mountain areas is mapped from satellite images for use in predicting water supplies, river flow, and flooding.

Through research now under way, satellites in the not too distant future may be identifying optimum fishing areas, monitoring ocean and coastal pollution, observing the state of the sea, and providing data for mapping the topography of the oceans.





(Opposite page) Snow fields and lakes in southeastern British Columbia appear in an Earth Resources Technology Satellite image. The lake to the right of the picture's center is lighter in tone than the other, because its waters contain more particulate matter. Satellite images of snow cover over mountain areas help in estimating future river flow.

Oceanographers have acquired some knowledge of the larger aspects of ocean circulation—such as major currents and their seasonal changes—by mapping aircraft, buoy, and ship observations and by means of such simple devices as drift bottles. But satellites, with their ability to make frequent observations of large areas, are ideal platforms for monitoring the constantly changing features of the global oceans.

Since 1965, NOAA, the National Aeronautics and Space Administration, the U.S. Navy, and other agencies have conducted research aimed at expanding the use of spacecraft to acquire new understanding of the oceans and their resources.

Within NOAA's National Environmental Satellite Service, two groups are engaged in various aspects of this research—the Environmental Sciences Group and the Spacecraft Oceanography Group. Other NOAA units working in satellite oceanography include the Atlantic Oceanographic and Meteorological Laboratories of NOAA's Environmental Research Laboratories; the National Marine Fisheries Service's Fisheries Engineering Laboratory at Bay St. Louis, Mississippi; and the National Ocean Survey.

Describing the work of the Environmental Sciences Group, Dr. E. Paul McClain, its Director, says: "Our mission is to develop non-meteorological applications of satellite data—principally of NOAA satellite data, but we also make use of data from NASA research satellites and, to a lesser extent, data from aircraft. We are confining ourselves to two non-meteorological types of remote-sensing applications—oceanography and hydrology—and emphasizing those that can be accomplished with data that are available or will be in the near future."

John W. Sherman, III, is manager of the Spacecraft Oceanography Group—called the

"SPOC Group"—which moved last year from the Navy to NOAA. Of this group, Mr. Sherman says: "Our project was begun in late 1965 with NASA funds, to give the oceanographic community representation in the NASA earth resources satellite program. In May 1972, the group was transferred to NOAA, because it was felt that its functions properly belonged in a civilian agency. We have sponsored investigators from universities, private industry, and government—and done a small amount of in-house research—in the areas of ocean dynamics, ocean color, sea ice, fisheries environment assessment, and coastal processes."

Up to the present time, as Mr. Sherman points out, "There have been no instruments put in space designed specifically for oceanography. Such use of satellite data has been peripheral, using instruments not designed to provide oceanographic data."

Television vidicon cameras that recorded patterns of reflected light were the primary sensors on the TIROS and ESSA spacecraft, and on the first NOAA satellite. During the 1960's, infrared scanning radiometers sensing heat energy emitted from the surface of the earth or sea or from cloud tops, and vertical temperature profile radiometers for sounding the atmosphere at various levels, made their debut in NASA's Nimbus series. Now, both techniques are in operational use on NOAA-2.

The year 1972 brought two major advances in environmental observation from space. The first Earth Resources Technology Satellite (ERTS-1) launched in July, senses in the green, red, and near-infrared portions of the spectrum, and a similar multispectral technique will be continued in Skylab, scheduled for launch in May. In December 1972, Nimbus-5 took the first two microwave sensors into space—one to map the thermal radiation emitted by the earth's surface and the atmosphere, and another for vertical sounding of the atmosphere. Many clouds which are opaque to infrared are transparent to the microwave region of the spectrum.

According to Dr. McClain, "Beginning with ERTS and the very high resolution radiometer on NOAA-2, we now have data whose spatial resolution is much more suitable for the applications that we are investigating. Data from the Nimbus satellites and the earlier operational spacecraft were of marginal usefulness to us. We were dealing with resolutions of two to five miles; now we're down to one-half mile in the case of the very high resolution radiometer and 330 feet in the case of ERTS. The latter is still of marginal usefulness because it photographs a given area 100 miles wide only every 18 days. Even then, you may not see the surface of the earth because of cloud cover. With NOAA-2 we have a good chance of seeing the same area several times a week, and furthermore we see a much larger area."

Each winter, sea, lake, and river ice closes ports and shipping lanes in high latitudes, forcing commercial vessels to remain idle and hampering military ship operations. To plan sea transport in these areas, marine interests need to know where ice exists in ports and along sea routes, and whether the ice is forming or breaking up. To provide this vitally needed information, the United States, Canada, and other nations operate aerial ice reconnaissance programs. Although this reconnaissance is complex and costly, the economic savings and increased safety afforded to shipping operations have justified the expense.

Knowledge of the existence and extent of sea ice also is important to the sciences of meteorology, hydrology, and oceanography. To the meteorologist, ice cover is an indicator of climatic change; it affects the heat balance of polar regions and ultimately influences the atmosphere and ocean on a global scale. To the hydrologist, ice may be a potential flood, its waters temporarily in storage. To the oceanographer, ice represents a danger to shipping, but it also affects living marine resources and can serve as a means of tracing ocean currents.

TIROS satellite photographs of ice in the Gulf of St. Lawrence were used as early as 1961 to route ships into Newfoundland. In 1962, the United States and Canada began a joint program—PROJECT TIREC, for TIROS Ice Reconnaissance—in which aerial and surface ice observations were coordinated with TIROS IV photography. TIREC led to the development of satellite ice reconnaissance techniques—using spacecraft data to permit more efficient aerial surveillance—which now are being applied operationally.

Later, an automated operational technique was developed by the National Environmental Satellite Service for mapping ice and snow boundaries from satellite pictures, resulting in a product known as a composite minimum brightness chart. In this technique, as Dr. McClain explains it, "The lowest brightness that occurs at any particular point during the compositing period—usually five days—is saved and is displayed at the end of the period. Snow is bright, ice is bright, clouds are bright, and everything else is much darker, whether it be land or ocean. If an area has neither snow nor ice, and is cloud-free even for just one day during the compositing period, it will appear dark, and that will be saved. Snow or ice will be bright throughout the period. By saving the lowest brightness, transitory cloudiness is removed, and the much more slowly changing ice and snow is retained.

"The Environmental Sciences Group," he says, "has devised ways to obtain from the brightness compositing technique some crude quantitative information about the concentration and condition of the ice packs. We did this by developing a way to calibrate the digitized brightnesses externally, since there is no way to calibrate them on board the satellite. We used external references, such as the Greenland ice pack and the cloud-free oceans as calibration points, and adjusted our data samples with respect to them. In this way, differences in brightness can be related to changes in the ice, either spatially or with time."

The use of vidicon camera systems for ice monitoring is handicapped by the lack of solar illumination during much of the cold half of the year. This limitation has been overcome by the introduction of thermal infrared sensors.

"With infrared data," McClain says, 'we can now observe major ice features throughout the year, in either hemisphere. The principal interest in ice during polar darkness is in knowing how much open water or very thin ice is present throughout the entire Arctic Basin, because this affects the energy balance. The amount of heat transferred to the atmosphere in an area where there is no ice is a hundred to a thousand times larger than where there is a thick ice cover. Very little is known about where, when, and how much of the Arctic is open at any particular time. The old idea that it was solidly covered by ice all winter long is not true. Now it is estimated that at least 10 percent of the Arctic is open at any given time.

"Furthermore," McClain continues, "the use of thermal data may enable additional information, such as the thickness or physical state of the ice, to be obtained or inferred. By enhancement of the infrared imagery, significant ice boundaries, openings, and thin areas can be detected. Experiments are being conducted to develop a multiday compositing technique for filtering clouds from these images, although this is proving more difficult than it was with the visible range data. The problem is that deep temperature inversions are common at high latitudes over land in winter, and some of the cloud tops are actually warmer than the earth's surface in nearby cloud-free areas."

Comparing simultaneous visible and near-infrared images received from Nimbus-3, launched by NASA in 1969, hydrologists and oceanographers in the Environmental Sciences Group noted some areas of ice or snow that appeared in the visible range, but did not show up in the infrared. Under normal conditions, snow and ice are highly reflective in both the visible and near-infrared areas of the spectrum. But when melting occurs, the near-infrared radiation is absorbed by the thin film of water at the surface of the ice or snow. The scientists now believe that comparison of simultaneous visible and near-infrared imagery—

Simultaneous visible (top left) and near-infrared images taken by Nimbus-3 over the Alps. The snow areas clearly delineated in the visible image all but disappear in the near-infrared, indicating that the snow is melting. (Right) In an ERTS-1 view of the Colorado River delta, sediment suspended in the upper layers of the water makes circulation patterns evident. (Far right) Algae appear bright in this ERTS near-infrared image of Utah Lake, and provide an indication of circulation patterns.

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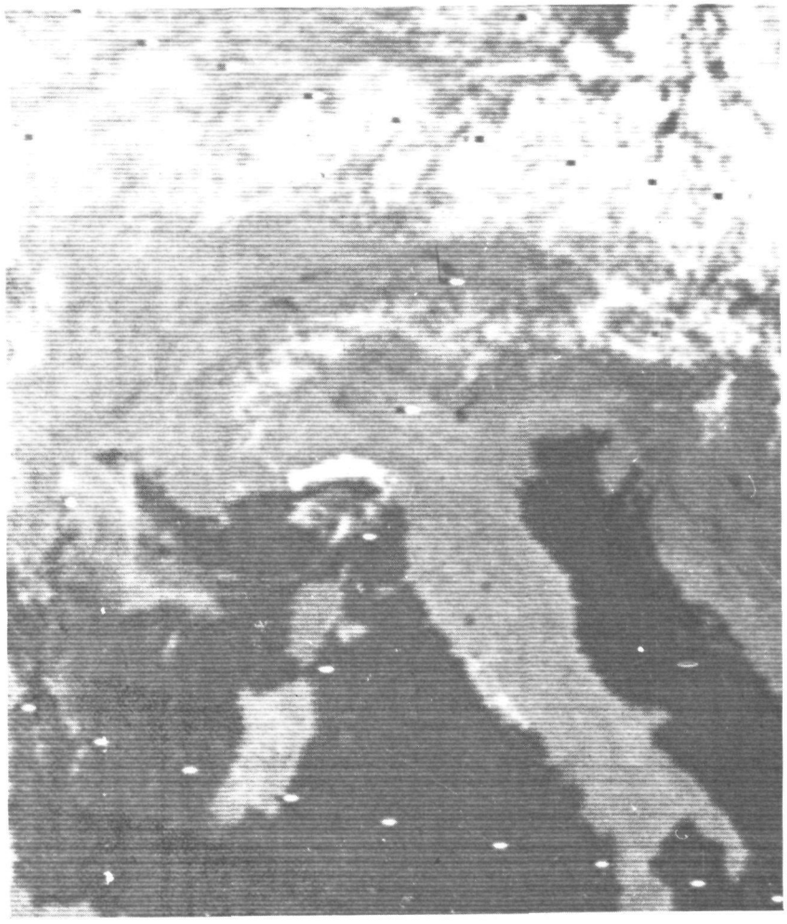
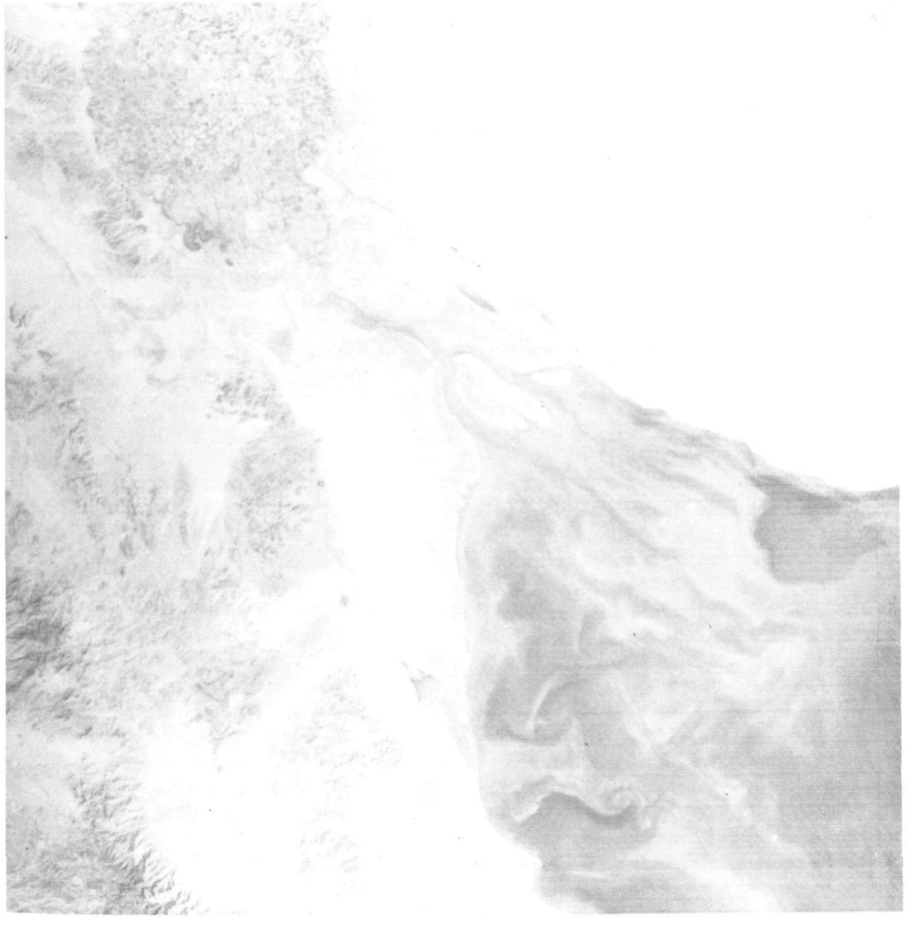




such as that provided by the ERTS satellites now, and which is planned for the next generation of NOAA satellites—is a promising method for monitoring melting snow and ice, and that it can assist in predicting snowpack runoff, forecasting floods, and assisting lake navigation.

Because of the pervasive cloud cover in polar regions, which visible and infrared sensors cannot penetrate, microwave systems capable of penetrating thin clouds have been considered and tested from aircraft as a means of observing ice. In the microwave region, unlike the infrared, the difference in emissivity—or brightness temperature—between ice and water is very large, even though their physical temperatures may be nearly the same. The microwave radiometer on Nimbus-5 will be used in experimental mapping of surface ice and water, but its resolution is relatively low—about 20 statute miles.

Of the Spacecraft Oceanography Group's work on sea ice, Mr. Sherman notes: "In our cooperative studies with NASA, we have had some very successful results, particularly in the aircraft program, with microwave instrumentation. We think that we can now discriminate between first-year ice and multiyear ice. A microwave system with sufficient resolution could very well be used in mapping major ice features and their dynamics.

"The data from NOAA-2's very high resolution radiometer shows that even a half mile of resolution can be extremely useful in assessing ice boundaries and major leads. From the orientation of these leads, it is possible to infer the types of strain that the ice has been subjected to by wind."

Minimum brightness compositing, two-channel detection of melting, the use of microwave sensors—developments that have advanced observation of the extent and composition of ice—also apply to the measurement of snow.

To forecast future river flow and flooding and to estimate potential water supplies, hydrologists in many areas must take into account the amount of water stored in the form of snow. In the United States—principally the West—seasonal snow accumulation is measured at thousands of surface locations and aircraft are used to survey snow cover over large regions. But only the broader view from space can give an accurate picture of the overall extent of snow cover.

Hydrologists in the Environmental Sciences Group have found that measurements of snow cover over mountain areas, derived from satellite photography, agree closely with measurements made by aerial surveys. Infrared sensors have detected new snowfall of less than one inch, appearing as a warm zone over older snow cover. The technique of comparing visible and near-infrared data to determine melting is particularly valuable in snow-covered mountain areas, where knowledge of the onset of snowmelt is vital for river and flood predictions and for water management.

Microwave sensing has applications in hydrology, too; the Environmental Sciences Group is supporting tests of such devices for measuring soil moisture, and is following closely similar work in the area of snow water equivalent being supported by the U.S. Geological Survey.

Another important aspect of oceanography, for which an operational product based on satellite data is now being issued on an experimental basis, is sea-surface temperature. Satellite observations of sea-surface temperature reveal many of the dynamic features of the sea, such as currents, meanders, eddies, and areas of upwelling and sinking water, providing information for the shipping and fishing industries, and for ocean researchers. The measurements are also important to atmospheric scientists, because of the close relationship between sea-surface temperatures and the earth's heat budget, weather, and climate.

Since the first infrared observations from space became available in the early 1960's, they have been used by oceanographers in NOAA and other agencies studying the sea. Observations from the scanning radiometer on NOAA-2 now are used to produce global analyses of sea-surface temperature to aid weather and marine environment forecast services. The technique was conceived and its feasibility established by the Environmental Sciences Group. The operational charts are a modified version produced by the Satellite Service's Computer Products Development Branch.

As Dr. McClain explains the concept: "Statistical techniques are applied to the aggregate of all infrared observations in a small area, say a degree of latitude on a side, over a period of five days. This may amount to a total of hundreds or even a few thousand individual observations. It is then statistically determined which of these observations are least contaminated by the presence of clouds in the field of view, and the estimate of sea-surface temperature is based on the least-contaminated observations. The resolution of the raw data is lost, but the ability to work in areas of partial cloud cover is gained. This is a necessity for producing analyses of temperature over a large area, a whole ocean, a whole hemisphere, or a whole globe. If there are any sizable openings in the clouds, at any time during the five-day period, a reasonable estimate of what the surface temperature was can be obtained."

The Group uses other techniques for enhancing infrared imagery for its special studies. "The infrared image normally displayed for meteorological purposes," Dr. McClain says, "does not portray the temperatures of the ocean surface in an optimum way. In fact, it may not display them at all. So what we do is truncate—throw away the part that is hotter or colder than what we are interested in—and then taking the remaining relatively restricted temperature range, utilize the entire gray tone range of the image over that smaller temperature range. In this way, we bring out the smaller temperature gradients at the ocean surface. Each step of gray to the next darker or lighter then portrays a change in temperature of a degree or so, instead of the five to ten degrees per step appearing in the usual meteorological display."

The National Environmental Satellite Service provides sea-surface temperature analyses or enhanced infrared images to the Atlantic Oceanographic and Meteorological Laboratories in Miami; to National Marine Fisheries Service laboratories in Florida, California, and New Jersey; to Woods Hole Oceanographic Institution; and to other groups studying the oceans and their resources.

Mr. Sherman of the SPOC Group looks forward to the flight in space of more advanced instruments for observing various aspects of ocean dynamics, such as sea-surface roughness and sea-surface topography.

"The study of sea-surface topography," he says, "is really measuring how 'unround' the ocean surface is. Even when the sea is calm, its surface can actually have a dip, due to geoid deflection caused by the mass located beneath the ocean. Over the Puerto Rican trench, there is a dip that is about 45 feet deeper at the center than at the sides—literally, a trench in the ocean surface. We think it's perfectly feasible to build a satellite altimeter to measure such depressions.

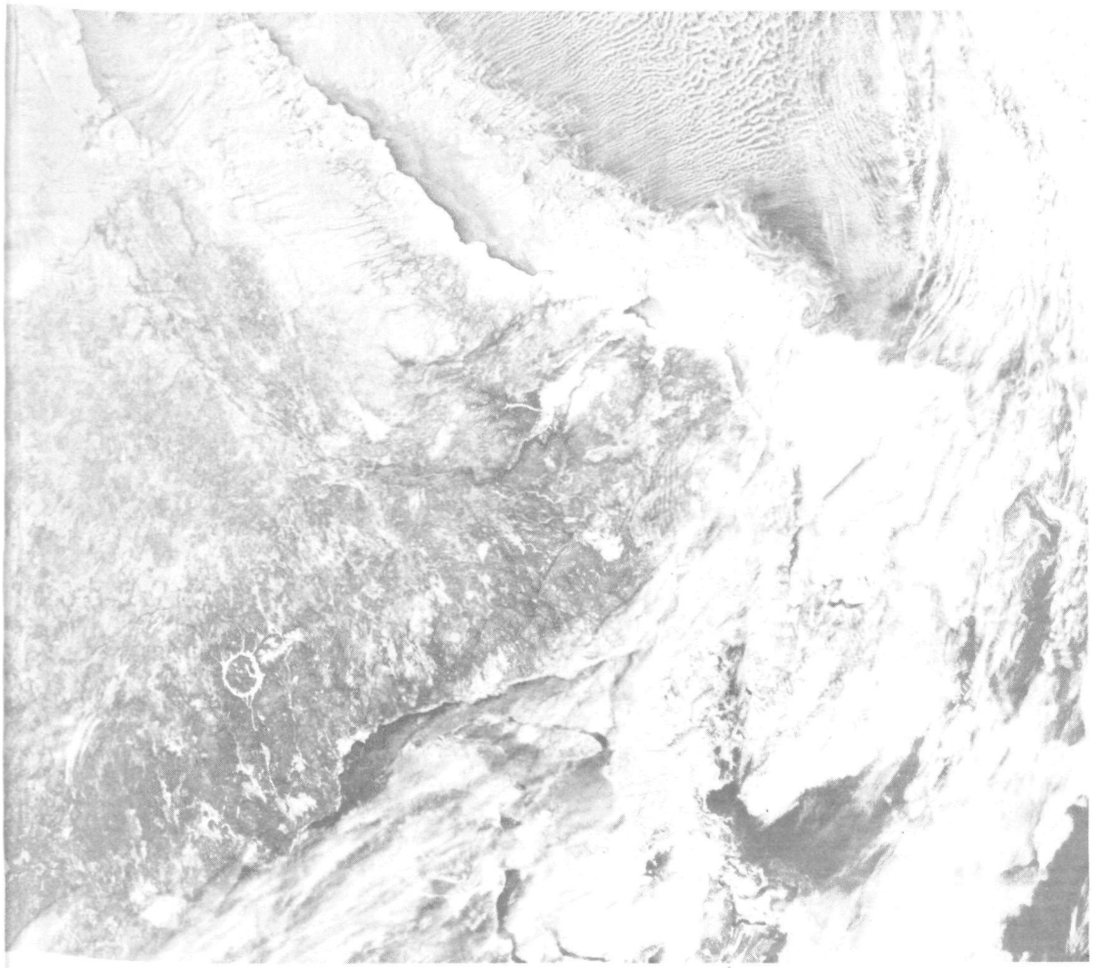
"The velocity of surface currents could be measured by such techniques. The Gulf Stream, for example, has roughly a three-foot slope. It's about three feet higher on the east side than it is on the west."

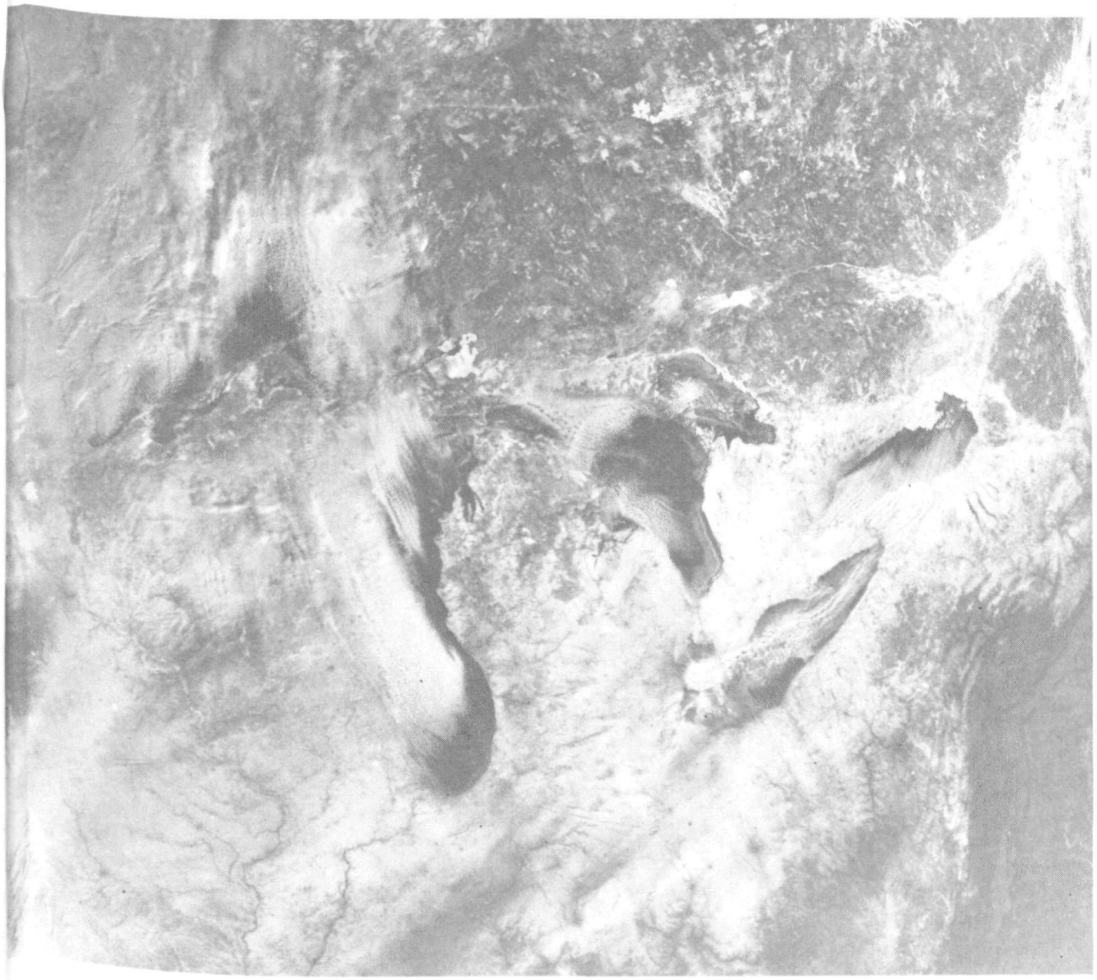
For more than a decade, scientists at the National Environmental Satellite Service have been examining available satellite data for clues to the state of the sea. Such information is vital to the safety and efficiency of shipping, and contributes to weather forecasts. The image of sunlight scattered at the sea surface appears in satellite photographs as "sun glint." Because the reflective properties of the ocean surface vary with wind and sea conditions, the size and brightness of the glint area correspond to the roughness of the ocean surface.

In photographs taken from the 22,500-mile altitude of the Applications Technology Satellites, the Environmental Sciences Group has found that the reflection pattern of the sun is spread over such a large area that varying sea surface conditions can be inferred in many areas within the tropics and subtropics.

"Of particular interest," according to McClain, "are patches or swaths of ocean surface that appear dark within the brighter sun-glint region. These dark swaths can be used to infer sea-state variations. In many cases, they correspond to calm air and smooth waters beneath high-pressure ridges or, when paralleling coastlines, the seaward limit of local sea-breeze circulations."

Widespread mapping of sea-surface roughness awaits the development of more advanced sensors than those currently in operation. Visual techniques are limited by certain geometric constraints and by





the cloud cover over the earth's marine areas. This has led to the study of passive microwave radiation and radar reflectance for sea state determination in the presence of clouds.

As Mr. Sherman points out, "The electronically scanning microwave radiometer on Nimbus-5 is measuring liquid and water vapor in the air column above the earth or sea surface. But over the ocean it probably is going to be very sensitive to foam on the surface, and this is directly related to the surface wind. We're very interested in studying the correlation between surface wind fields and the microwave brightness temperatures that come back from Nimbus."

Ocean color, too, provides clues to the dynamic motions of the sea, such as currents and upwelling, but also contributes information on bottom topography, coastal processes, effluent patterns, and biological productivity.

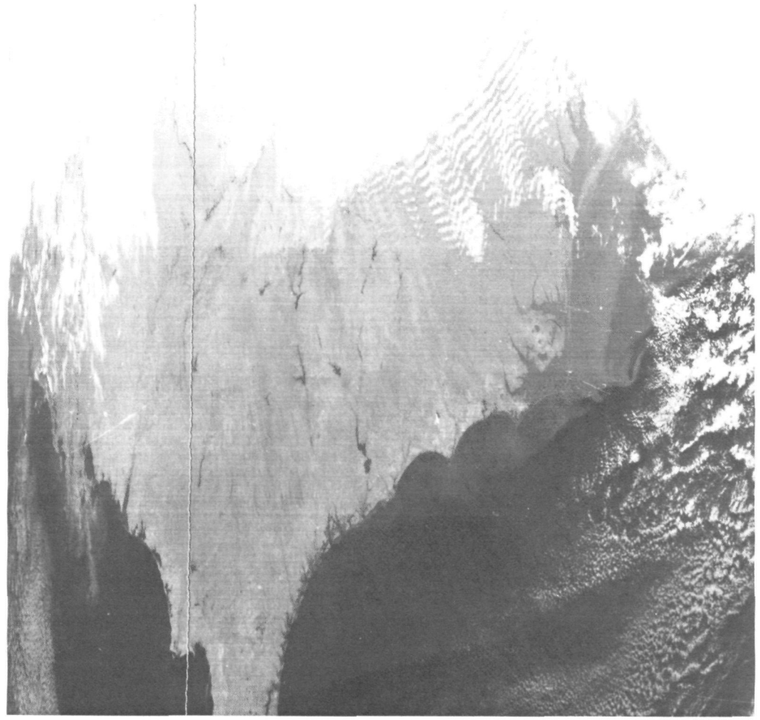
NOAA scientists are using the multispectral data provided by the Earth Resources Technology Satellite in studies of sea ice distribution, snow runoff potential, circulation and surface characteristics of oceans, lakes, and bays, air and water pollutants, fishery resources, and other applications.

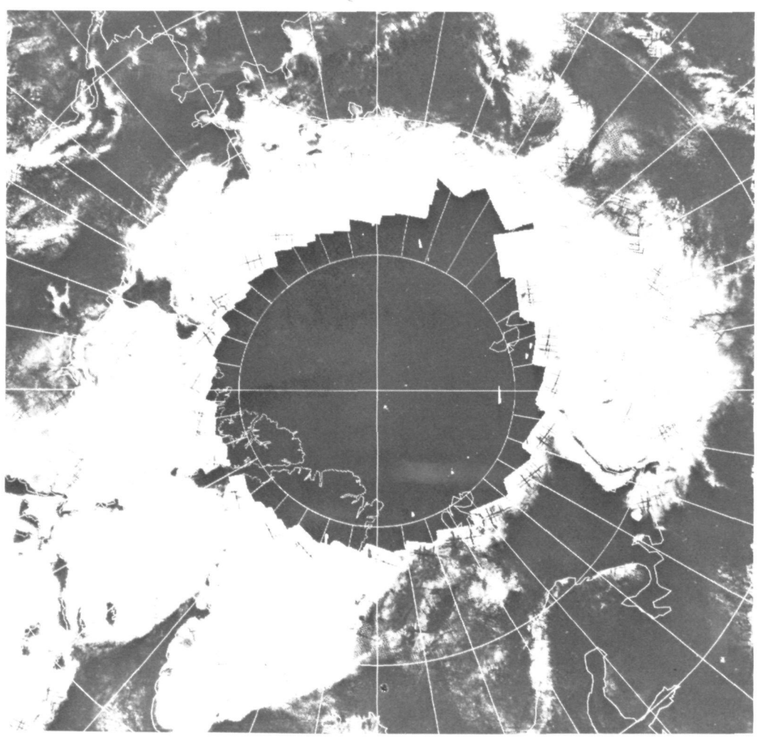
"The Spacecraft Oceanography Group uses ocean color primarily from the biological standpoint," Sherman notes, "because —in the oceans as a whole, once you get away from the immediate coastal regions— chlorophyll by and large determines ocean color. The more chlorophyll in ocean water, the greener it becomes.

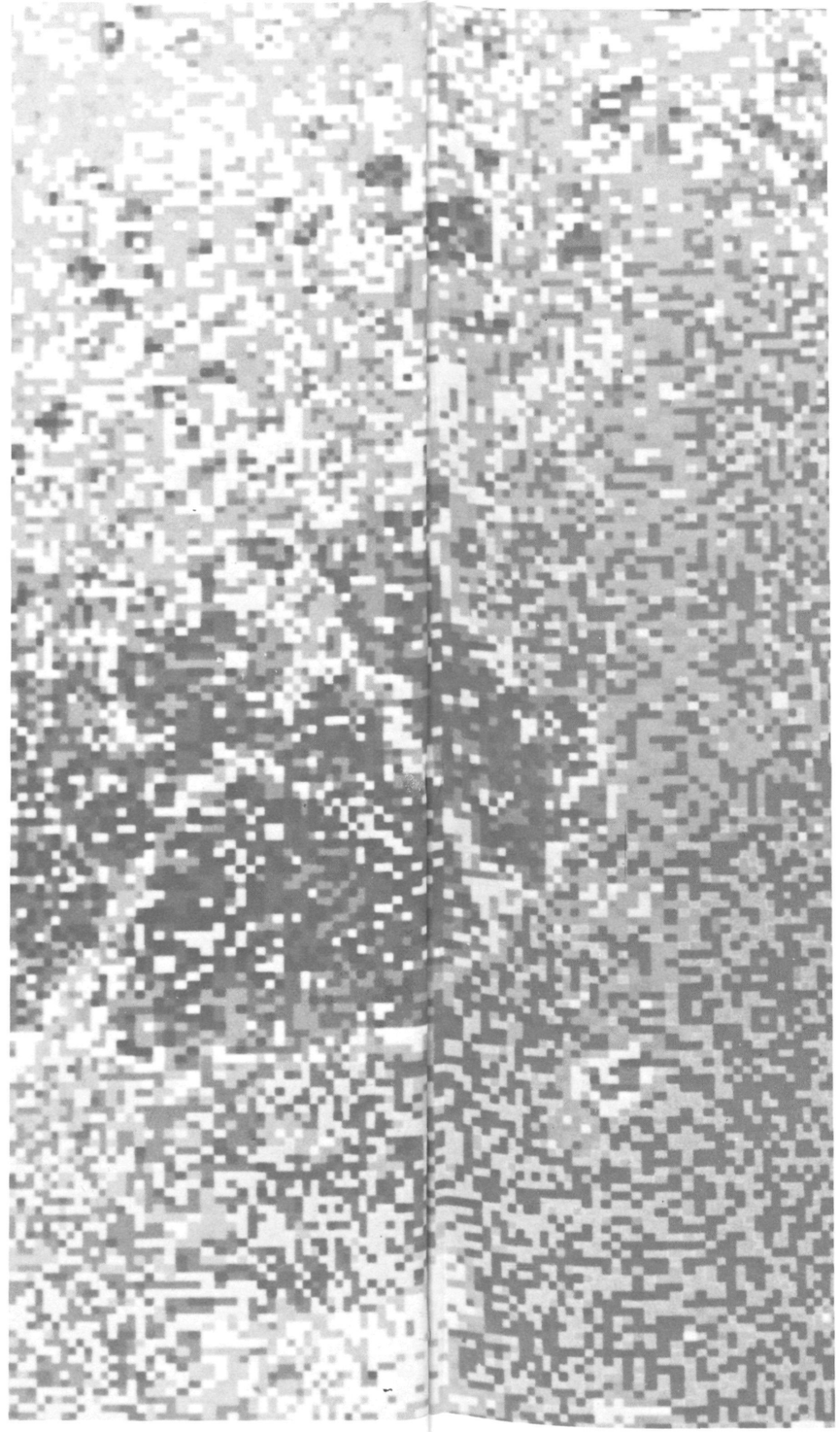
"Ocean color can be used for current mapping. Ocean currents inherently have different types of nutrients, different temperatures, the biology is different, and there is good reason to believe that they have different chlorophyll concentrations. A case in point is the Gulf Stream. The human eye cannot always see the Gulf Stream, but sensitive instrumentation can make a distinction between Gulf Stream water and the coastal and slope water, especially on the west side of the current.

"Chlorophyll differences in biologically rich near-coastal waters are important to fisheries," he continues. "The open ocean, though, also has some chlorophyll in it. If we are really interested in ecosystems

(Top) Pack ice along the Labrador coast appears in an image from NOAA-2's very high resolution radiometer, which has a resolution of one-half mile. (Bottom) Very high resolution radiometer image of the Great Lakes and St. Lawrence Seaway shows widespread snow cover and frozen and unfrozen lakes and streams.







analysis on a global basis and the effects of man's activities—for example, the impact of DDT on the oceans—until we can measure chlorophyll, or productivity, on a global basis, we simply are not going to be able to assess these effects. In the future, we may be able to measure very low chlorophyll concentrations and be able to determine pollution impact."

"The prime application of ocean color," Mr. Sherman points out, "is to fisheries. Data on ocean color allows the fishing industry to identify water mass boundaries, where there are differences in chlorophyll content and temperature. There appears to be a very strong correlation between ocean temperature and fish catch."

"In a sense, fisheries is the only resource that we deal with in oceanography, so far as the earth resources survey program is concerned. It's very hard to relate remote sensing directly to minerals, mineral deposits, or petroleum mining. Indirectly we can help through forecasting sea-state conditions important to routing of tankers that might be carying oil, and in providing sea-state data needed for design and development of offshore drilling rigs.

"Our work in fisheries environment assessment is really a composite analysis for fisheries of both ocean dynamics—particularly sea-surface temperature—and ocean color. The Spacecraft Oceanography Group is also interested in direct fish-detection techniques, such as detection of bioluminescence by instruments on ships and aircraft."

The lead laboratory for fisheries environment assessment is the National Marine Fisheries Service's Fisheries Engineering Laboratory, established in 1970.

The Laboratory has been studying the application to fisheries of such remote sensing techniques as low-light-level image intensifiers, spectrometers, aerial photography, and lasers for the location, identification, and quantification of living marine resources at or near the sea surface. In addition the Laboratory is participating in space oceanography studies related to fisheries, including experiments with ERTS and the forthcoming Skylab.

"The study of coastal processes," Mr. Sherman believes, "is an area where there can be immediate application of satellite data—infrared data from NOAA satellites, as well as the ERTS type of information. In the coastal region, there is quite a bit of suspended sediment in addition to chlorophyll. Because many natural as well as manmade things color the water, multispectral images can be used in current mapping and identification of major water masses in the coastal region. Repeated observations can show areas where changes are occurring and areas where the environment is stable.

"The long-term impact of pollution," he continues, "can, in part, be monitored by an ERTS-type system. And there's reason to believe that major oil spills might be picked up with this type of satellite.

"In this area, the Naval Research Laboratory has a very interesting microwave project, sponsored by the Spacecraft Oceanography Group and by the Coast Guard. With a three-frequency microwave radiometer system flown on an aircraft, the thickness of the oil on the surface can actually be measured. Although an oil slick may run for miles and miles, some 80 percent of the oil may be concentrated in five percent of the area. Those who are responsible for cleaning the oil up aren't interested in knowing the boundaries of the slick, but where the oil is concentrated.

"Circulation studies in the coastal region," Mr. Sherman believes, "are probably going to be the biggest application of ERTS to the ocean community. It should be possible to make some estimates of suspended sediment concentrations and of the depths of sediments, based on ERTS data.

"ERTS can do one thing that we really haven't had the capability to do before in the coastal region—and that's identify where the major frontal systems are. Then you know where to set up your surface instrumentation.

"We will be using ERTS in this way for the Marine Ecosystems Analysis program in the New York Bight this spring. All SPOC Group coastal processes investigators will be brought into the New York Bight area to contribute to this program. We will be doing surface circulation analysis, measuring chlorophyll with some multispectral scanners on board aircraft, and measuring turbidity, salinity, and other forms of suspended particulate matter."

As to what the future holds for satellite oceanography, among the possibilities Mr. Sherman foresees are the operational use of instrumentation to monitor ocean color, microwave instruments to monitor surface wind fields, radar altimeters for mapping sea-surface topography, microwave sensors for all-weather observations of sea ice and ocean roughness, and instruments that will provide information on sea-air interaction and the processes leading to the formation of tropical storms.

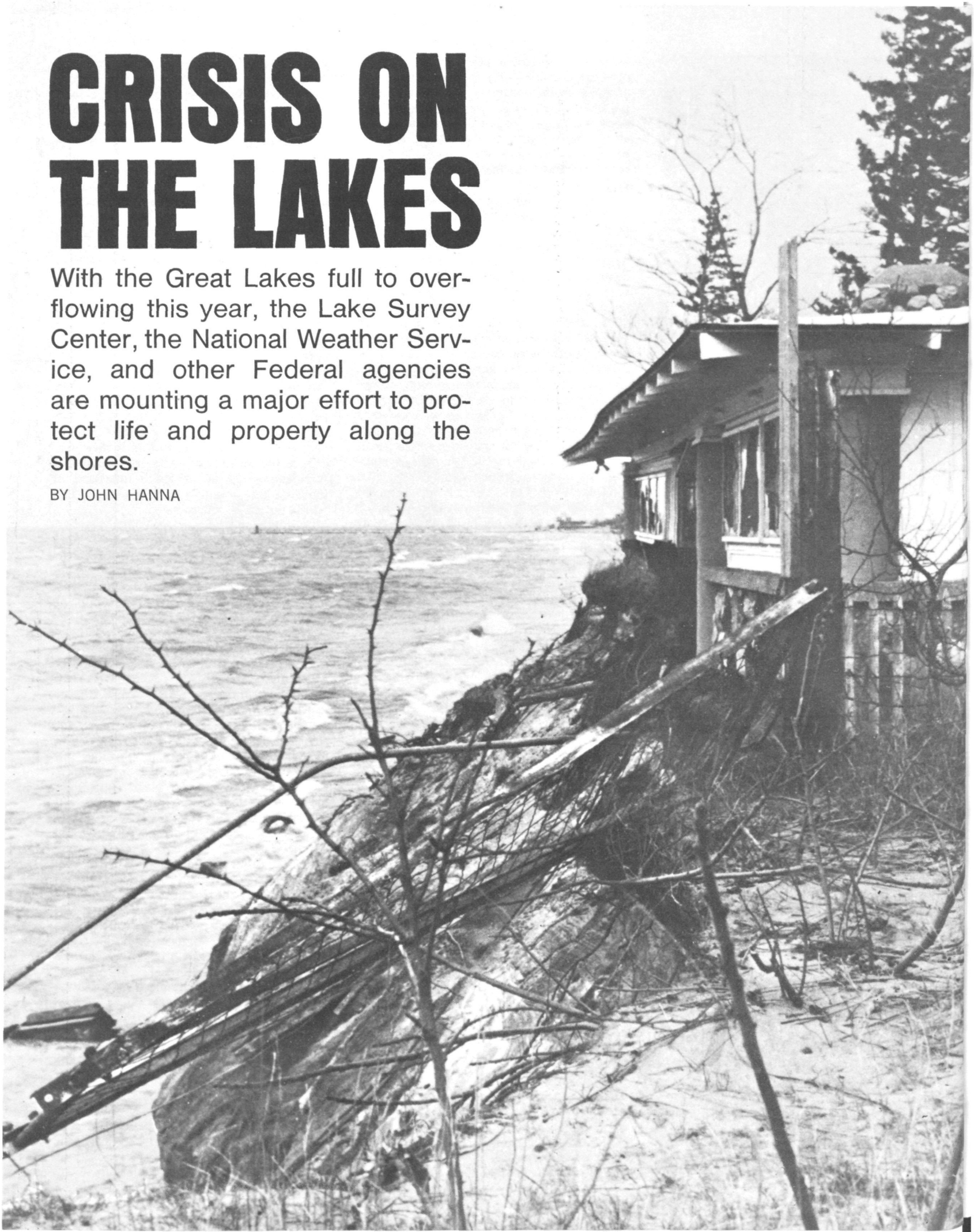
Even before remote sensing advances so far, the forthcoming Geostationary Operational Environmental Satellite system will be collecting and relaying data from such unmanned platforms as river gages and ocean buoys—adding a new capability in satellite oceanography and hydrology. □

(Top left) Very high resolution radiometer image from NOAA-2 covers the eastern Gulf coast, northern Florida, and the Atlantic coast northeastward to the Chesapeake Bay vicinity. The warm waters of the Gulf Stream appear black. (Lower right) In a 10-day composite minimum brightness chart of the northern polar regions; based on ESSA-9 pictures, the brightest areas are snow fields over land and ice fields over lakes and oceans. There is no data over the pole, because of lack of sufficient sunlight. (Left) Microwave image of Arctic sea ice was obtained through clouds from an aircraft. Darkest areas are multiyear ice, while the lightest are first-year ice.

CRISIS ON THE LAKES

With the Great Lakes full to overflowing this year, the Lake Survey Center, the National Weather Service, and other Federal agencies are mounting a major effort to protect life and property along the shores.

BY JOHN HANNA



Great Lakes shoreline residents may wish for a little Dutch boy before 1973 is over, but it will take more than a finger in the dike to prevent serious flooding and more erosion this spring and summer.

The storm of November 14, 1972, vividly brought the seriousness of the situation to the public's attention. This nor'easter caused flooding along the shore of Lake Erie, Lake St. Clair, and Lake Huron's Saginaw Bay. It may have been Mother Nature's way of giving a little early warning—a sample of things to come.

At the height of the storm, Lake Survey water-level gaging stations at opposite ends of Lake Erie showed a difference of over eight feet. The one at Buffalo recorded −12 inches and Toledo's, +88 inches. Because of the strong winds, water levels at the west end of the lake had risen four feet above their already record highs.

Timely warnings by the National Weather Service were instrumental in the evacuation of many people in the threatened areas. Initial warnings were issued 16 hours before highest water levels and, although the unavoidable loss of property amounted to an estimated $22 million, not a single life was lost.

At the time of the storm, Lake Erie was about five inches above the record set in 1861 and was over two feet above its long-term average. Because it is the shallowest of the Great Lakes, Erie is particularly susceptible to such wind set-ups and also an occasional seiche. Its general northeast-southwest alignment, roughly parallel to the prevailing wind, contributes to the lake's habit of "tilting." These phenomena cause extensive flooding in the very low-lying land areas adjacent to the lake. In the most seriously affected areas, the land rises only a few feet for a considerable distance from the shoreline.

The rest of the lakes are not much better off, and the forecast indicates little relief. At the end of December, Lake Erie was about 8½ inches above the record for that month, and the outlook is for it to equal or exceed previous records for each month through June 1973. Lake St. Clair set records in the last three months of 1972 and is expected to be over four inches higher at the end of June than its highest of '72. At the end of June, both Lakes Michigan and Huron are forecast to be 17 inches above their long-term averages, about 4 inches above 1972's highest but still about a foot and a half below the record for June which was set in 1886. Even though the torrential rains of tropical storm Agnes helped to raise the level of Lake Ontario dramatically last year, forecasters are predicting levels by the end of June to be nearly seven inches higher than the high of '72. Almost any storm out of the north will cause problems for New York State residents on the south shore. Lake Superior—which fluctuates the least, partially because of its size and normally peaks several months later than the rest—is expected to be slightly below its June '72 level by the end of June 1973, but still rising.

Who is hurt and who benefits from high lake levels?

One method for making electricity is to pass water from a higher level through giant turbines to a lower level. In 1964, because of extremely low lake levels, hydroelectric power plants had to activate coal-fired generators to meet the demand for electricity. Low flows haven't been a problem recently. As a matter of fact, hydroelectric power companies will literally have more water than they know what to do with this year.

Higher levels mean that commercial vessels can carry more cargo. Shipping companies now are planning to "load 'em to the gunnels" in 1973.

The high levels do create certain difficulties for the mariner. Sand bars, old pilings, and similar hazards to navigation that may have been visible a few years ago now lurk just under the water's surface, waiting for the unwary boatman. Fixed bridges pose another problem; clearances for most are

(Opposite page) Summer cottage clings to the edge of a wave-eroded bluff. (Below) Wind-driven waves attack Great Lakes shore. Detroit News photo.

based on chart datum but, with actual depths anywhere from two to five feet above charted depths, a bridge's clearance could be as much as five feet less than that listed in official nautical publications. During high water periods, special speed restrictions are often imposed on rivers, channels, and other limited maneuvering areas, primarily for the protection of shoreline property and structures.

Shoreline property owners, both residential and commercial, are victims of high lake levels. The two major areas of concern are erosion and flooding.

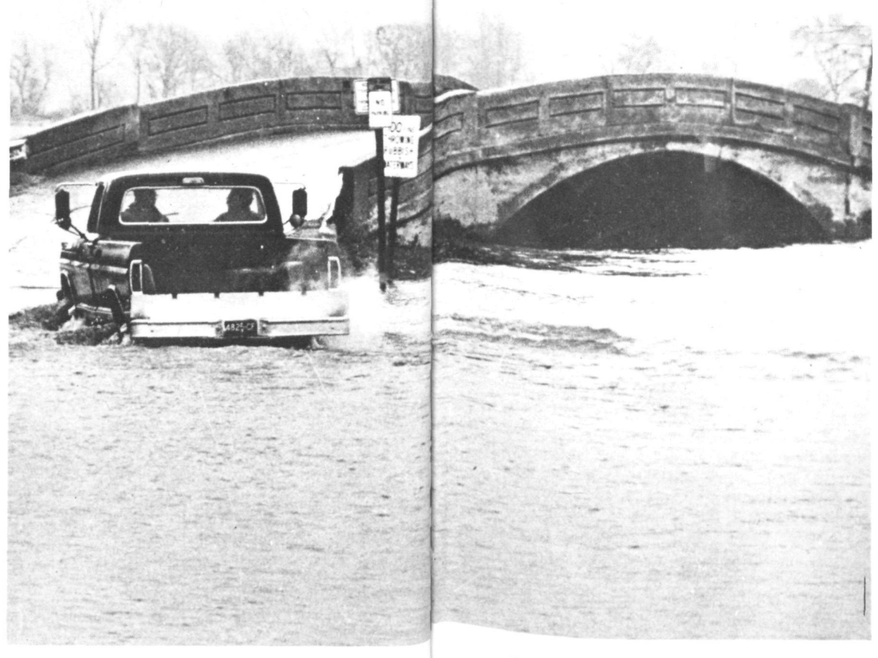
Not counting islands and connecting waterways, there are about 3,700 miles of U.S. shoreline in the Great Lakes. Counting everything, including the Canadian side, there are over 10,000 miles of shoreline in the system. Of these the Corps of Engineers estimates that 1,300 miles are subject to significant erosion, 200 miles to critical erosion, and 300 miles to flooding.

What can be done about flooding and erosion? A number of Federal agencies are working directly on these problems: the Office of Emergency Preparedness; two NOAA units—National Weather Service and NOS's Lake Survey Center; Great Lakes-based U.S. Army Corps of Engineers Districts; the Small Business Administration; Department of Housing and Urban Development; and others. The SBA provides low-interest loans for flood-damaged property under certain circumstances. HUD, through private insurance companies, subsidizes a flood-insurance program specifically for endangered communities.

The Corps of Engineers has the function that is perhaps most visible to the public during this emergency period. The Corps' "Operation Foresight" evolved from Public Law 99 which, in part, reads as follows: "Be it enacted by the Senate and the House of Representatives—That there is hereby authorized an emergency fund in the amount of $15,000,000 to be expended in flood emergency preparation. . . ." It has been estimated that $230 million in flood damages primarily along the upper Mississippi River were prevented by "Operation Foresight" in 1969 and 1971. Some of the guidelines are that such flood protective works must be beyond state or local capability, found justified from the economic and engineering standpoint, and be designed to cope with expected high water levels.

The unique thing about the law is that the impetus for action comes from local government and the citizen. In other words, threatened municipalities must take the initiative. In Michigan, for example, they deal with the State's Department of Natural Resources, which is the designated coordinating agency for "Operation Foresight." As such, that agency provides liaison between the Corps of Engineers and local communities. Requests for assistance go to the Department of Natural Resources for review and forwarding to the Corps. Before assistance can be considered, all rights-of-way must be granted at no cost to the Government, the U.S. must be held and

(Above) High lake levels and strong winds produce flooding in low-lying areas near the shore. (Above right) Citizens take emergency measures to protect their property against wind-driven lake waters. (Right) High waters flood roads and reduce bridge clearances. (Below) Michigan State Highway Department builds emergency works to protect highway from erosion. Detroit News photos.



saved free from damages, and all works constructed at Federal expense must be maintained and removed, as appropriate.

The Detroit unit, one of the most active Corps of Engineers Districts on "Foresight" in the Great Lakes, has conducted numerous meetings wtih local governmental bodies, the purpose being to acquaint them with "Foresight" and explain how they go about getting assistance. It has concentrated on flood-prone areas such as those hard-hit during the November storm. In addition to helping in the design and construction of temporary dikes, the Corps offers technical advice on preparation of flood protection plans, loan of equipment and supplies, and will assume operational control and direction of emergency work if requested. Flood protective works constructed in this year's Great Lakes effort are designed to withstand fall storms, as well as those which may occur this spring and summer. No one can foresee how many lives will be saved, but early estimates indicate that the amount of property damage prevented will reach significant figures.

The law which authorized "Operation Foresight" is very clear on one point. It specifically exempts beach and shore erosion from the program, even though damage from these forces is probably at an all-time high. Today's levels are at, or near, those reached in '52—the last period of high water. During the intervening 21 years, most Great Lakes shoreline areas have undergone extensive development. In fact, the low levels of 1963, '64, and '65 which generally produced wide, sandy beaches probably induced many to build too close to the edge of a bluff or too near the water. Structures range from simple frame cottages to elaborate year-round dwellings.

Some types of commercial property were constructed with the same lack of planning which characterized private development. Some small-craft piers and docks built then are now actually under water. Even certain state installations are not immune to the problems caused by high water. The State of Michigan, for example, had to place a retaining wall and erect groins to protect a section of highway from the rampaging waters of Lake Michigan.

Groins are usually rock-filled cribs, steel sheet piling, or similar structures which protrdue from the shoreline. Their purpose is to trap sand moving along the beach. Shoreline residents have tried practically anything and everything to protect their property. Some have dumped broken concrete, rocks, and even old car bodies into the surf zone in an attempt to halt damaging wave action. Others, at considerable expense, have had steel-sheet seawalls constructed and groins built with some success.

The Corps of Engineers, although sympathetic to their plight, can offer only expert engineering and technical advice. The best example is a published booklet titled "Shoreline Damage—Causes and Protective Measures." It is free and has been distributed widely in the Great Lakes area. Although the Corps cannot act in the case of private property, it has—in certain cases and to varying degrees—the authority to take action where public or "accessible-to-the-public" lands are involved.

National Weather Service forecast officers in the Great Lakes area have been alerted to the spring flood potential, and focal points have been assigned to coordinate their efforts. Arrangements have been made to work with the Office of Emergency Preparedness and local agencies in alerting the public to the potential hazard, as well as to what steps NWS will take if a dangerous situation develops.

The Weather Service has made arrangements to have data from key Lake Survey Center-NOS water-level gage sites relayed directly to area forecast offices. Lake Survey Center operates and maintains over 50 water-level gaging stations around the Great Lakes and has historical records dating back to 1860. Knowing wind direction and force, and being able to detect gradual rises in levels at one end of a lake as wind set-ups occur, meteorologists will be able to anticipate and warn of critical conditions.

Lake Survey issues a weekly water-level report, and a Monthly Bulletin of Lake Levels which contains information on current levels plus a Corps of Engineers-prepared six-month forecast of levels.

Nature has contrived to give the Great Lakes area an overabundance of precipitation. Thus, even though outflow rivers are discharging near-maximum volumes of water, the Lakes continue to rise.

The outflows from two of the Great Lakes—Superior and Ontario—are controlled by special groups under the International Joint Commission. By regulating outflows some control of lake levels can be achieved during periods of normal precipitation. During abnormal periods, either high or low rainfall, little control of levels can be accomplished, although every attempt is made to keep them within a specified range.

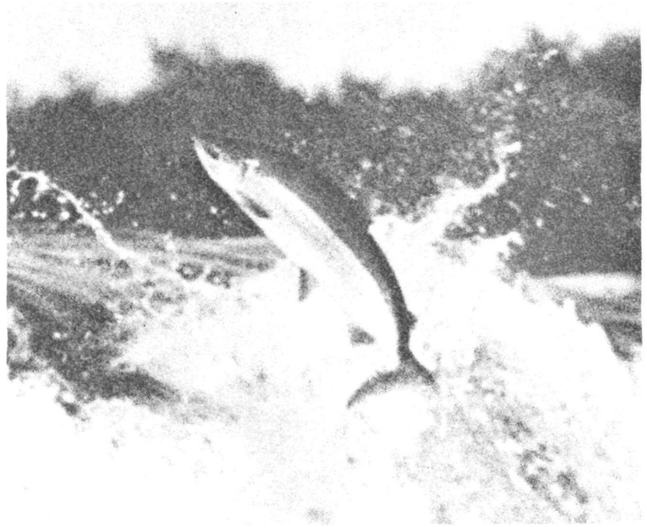
The seriousness of the present situation and the great public concern have given rise to a variety of schemes to lower lake levels. Eight years ago, the opposite was true. Then it seemed as though nearly everyone had an idea of how to raise levels. Today, some plans to lower levels are pretty farfetched. Others—such as adjusting diversions into and out of the Lakes—can reduce levels slightly but cannot be considered cure-alls.

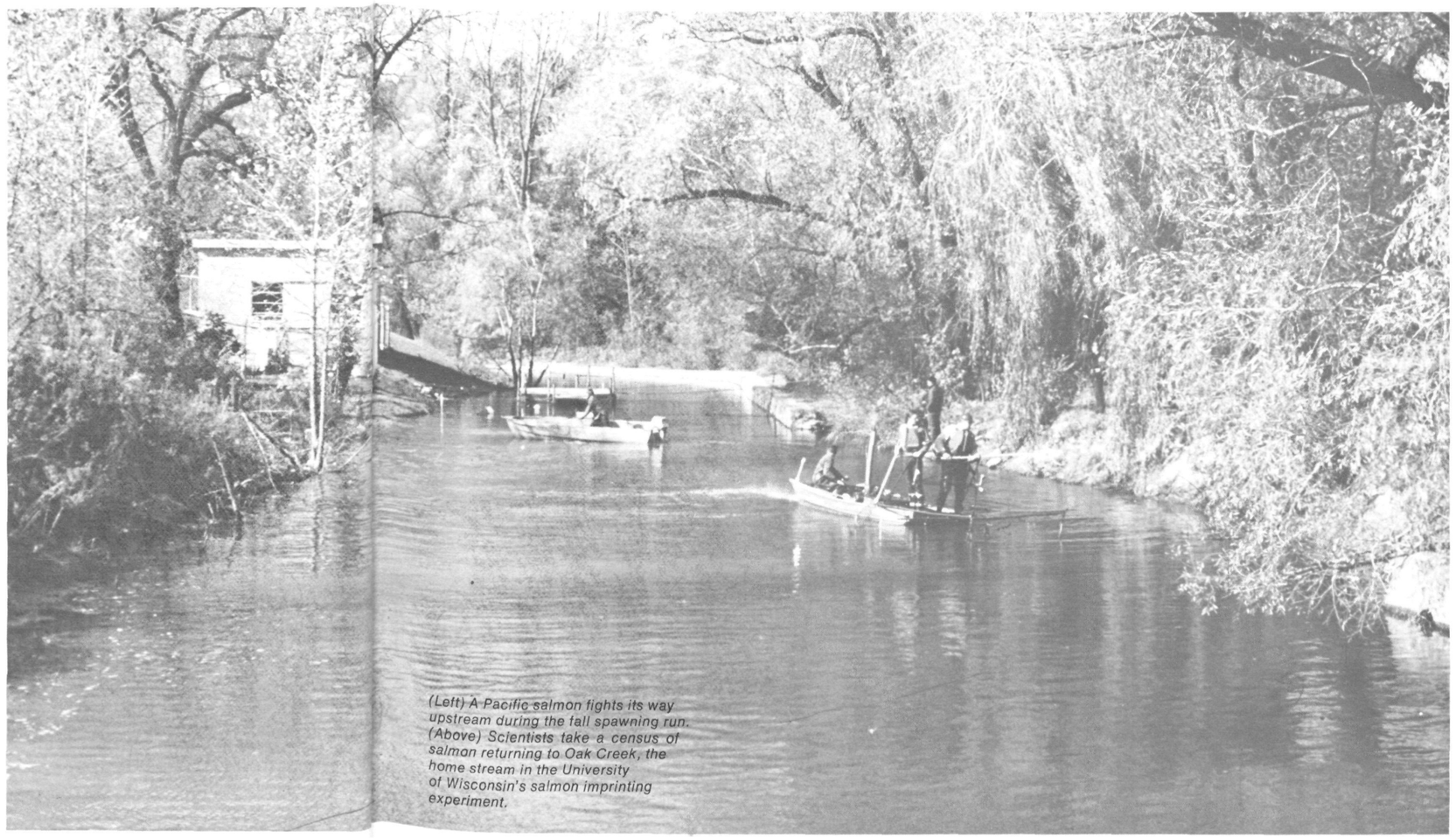
Technology these days is advancing at a tremendous rate. Possible solutions to controlling nature and natural disaster phenomena or at least significantly reducing their effects may be closer than many realize. Until that day arrives, however, the best answer to such problems is to provide an adequate warning system, provide complete information on protective measures which can be taken and, where necessary, take action on the Federal level to provide either protection or relief. □

How do salmon find their native streams? Sea Grant studies at the University of Wisconsin indicate that the odor of water plays a large role.

TRACKING THE SALMON HOME

BY LINDA WEIMER*





(Left) A Pacific salmon fights its way upstream during the fall spawning run. (Above) Scientists take a census of salmon returning to Oak Creek, the home stream in the University of Wisconsin's salmon imprinting experiment.

Long before the time of man, the salmon ranged throughout the far reaches of the Northern Hemisphere. With great endurance and an uncanny sense of direction, these magnificent fish existed then much as they do now, save for one important factor—man.

Even primitive man knew the salmon well. No doubt, they were an important feature in his diet and, in return, he adorned the walls of his caves with their portraits. In fact, there are striking parallels between those crude pictures and today's familiar photograph of the proud fisherman with his 30-pound salmon catch.

Man's relationship with the salmon has lasted tens of thousands of years. And throughout that time, the fish, though familiar and useful to man, has proven an enigma to him. Even today, parts of the salmon's life cycle are a puzzle filled with unanswered questions.

Every year Pacific salmon, by the millions, forfeit their lives in an incredible journey. Across many miles of open water and up through a maze of rivers, they travel back to the streams of their birth. There, energies spent, they spawn and die.

The mystery remains—how do they find their way home, sometimes from thousands of miles out to sea? What guides the salmon to that one stream in ten thousand that is his native stream? What could possibly compel a huge chinook to hurl himself again and again to surmount a raging waterfall, until he is battered, bruised, and exhausted?

With support from NOAA through the Sea Grant program, scientists at the University of Wisconsin are closer than man has ever been to solving parts of the salmon puzzle, though some answers remain as elusive as they were centuries ago.

For nearly 30 years, a series of research teams under the direction of limnologist Arthur D. Hasler has been investigating salmon migration. They have observed, raised, tagged, tracked, dissected, and lived with the salmon and other fishes in their efforts to understand migration behavior, realizing that such knowledge is essential for the protection and wise management of our valuable fisheries resources.

Many years ago, Hasler proposed that, having encountered the home river, the fish might be relying on their sense of smell to identify the right tributary.

His theory was based, in part, on observation and on knowledge of fish migration and olfaction uncovered by other scientists before him. But it was also based on intuition.

"As a boy, I used to hike in the mountains near my home. When I returned there as an adult with my own children, I took them hiking along a path I had frequented as a boy. As we hiked along, the familiar fragrances of columbine and mosses growing near a waterfall lying ahead, just out of sight, triggered a whole flood of memories. The names of my boyhood pals, and the nearby mountain meadow where we used to play baseball, flashed across my mind in the most vivid detail."

This type of experience is common to all of us, but it happened to Arthur Hasler at a time when he was doing a lot of experimenting and thinking about the role of the sense of smell in fish. This incident, among other things, led him to suggest that odors might be triggering the salmon's memories of his home stream, just as they trigger memories in the minds of men.

He and his students—particularly Warren Wisby, now at the University of Miami—subsequently showed that each stream has characteristic aromas which stem from the soils and plant communities of its drainage basin. Hasler reasoned that the salmon learns, or is imprinted to, these odors as it is growing up in the stream, and recalls them later as a spawning adult.

During the fifties and sixties, with support from the Office of Naval Research, the Wisconsin team conducted a series of experiments in the laboratory and in the rivers of Washington State which lent support to this theory.

In one experiment, they took spawning salmon that had already migrated back to their home streams and plugged the noses of half the fish, leaving the other half alone as a control group. They then released the fish back downstream, below a fork in the river, and let them repeat their homeward journeys. The researchers found that the treated fish became confused and could not find their way back home with any accuracy, while a high proportion of the control fish made the journey back successfully.

These and similar results lent support to the odor hypothesis. If it was true that odor was guiding the fish, Hasler proposed, it should be possible to scent a stream with a synthetic odor, imprint the fish to it, and then decoy them back to another, nearby stream instead, simply by adding small amounts of the chemical into the water.

The main problem was finding the chemical to do the job.

"We needed a substance that would neither attract nor repel the fish," says Hasler, "but it had to be soluble, fairly stable, and detectable in minute quantities—for example, one drop in an average-sized swimming pool."

"We specified the experiment to be done, and ultimately Warren Wisby even found the chemical to do it," he says, "but, though several scientists from other universities expressed interest, the idea was never successfully carried through."

Several years ago, the Michigan Department of Natural Resources, and later the Wisconsin Department of Natural Resources, brought the Pacific salmon to the Great Lakes.

Pacific stocks of coho and chinook salmon were planted in Lake Michigan to replenish the supply of sports fish which had been decimated by the sea lamprey invasion some years earlier, and to help prey upon the exploding alewife populations.

Because salmon can't spawn naturally in the silty, turbid streams flowing into Lake Michigan, the Department of Natural Resources now raises the fish in hatcheries until they are eighteen months old. Then, it releases the fish into selected holding ponds along the streams that feed into Lake Michigan. At this time, the fish undergo a process called smolting and begin their downstream movements into the lake, to start their new

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* Linda Weimer is an editor in the University of Wisconsin's Sea Grant Communications Office.

lives in the inland oceans.

The salmon's arrival gave Hasler's group the perfect opportunity to try the crucial decoy test of the odor theory right in their own backyard.

In cooperation with the Wisconsin Department of Natural Resources, and with support from Sea Grant and the National Science Foundation, the scientists raised a group of salmon at a water filtration plant in south Milwaukee.

The fish were raised in water piped in from Lake Michigan, which did not contain any home stream characteristics. For one month prior to the smolting period and their release, half the fish were exposed to the imprinting chemical; the other half were left alone as a control group. All the fish were then tagged and released into the lake at a point nearby.

During the fall spawning runs of 1971 and 1972, the scientists dripped small amounts of the imprinting chemical into Milwaukee's Oak Creek, in the hopes that imprinted salmon, when mature, would be drawn back by the odor.

But the proportions of imprinted versus control fish in the returns were unclear, and the data yielded no firm conclusions. In the spring of 1972, the group tried a new tack. For one thing, they raised and released the fish much further away from Oak Creek, the experimental "home stream."

"We also held the fish a little longer and exposed them to a longer imprinting period," notes field team leader Dale Madison.

This past fall, the jacks or precocious males from the last spring's release returned to Oak Creek. These returns exceeded the scientists' most optimistic expectations. Twenty times as many imprinted as control fish returned. Although most of the fish from this release won't return until they are adults next fall, the preliminary results strongly support the theory that it is the chemical odor which is attracting the fish back.

The scientists also have physiological studies and behavioral evidence that bear this out.

Allen Scholz, a field assistant, tracked a number of fish, both imprinted and controls, past the mouth of a small stream which contained some of the imprinting chemical. They found that the imprinted fish stopped short and milled around the area, while the controls swam right on by. When the chemical was removed, both the imprinted and control fish swam by without stopping.

In the laboratory, graduate student Jon Cooper has been performing a delicate operation on the coho. Using techniques developed by his predecessor Andrew Dizon, Cooper bathes the fish's nose in a variety of solutions, each containing a different odor substance. A tiny electrode is planted in an olfactory bulb in the fish's brain. The fish's reactions to each chemical are then recorded on polygraph, to which the electrodes are attached. He has found that the responses are most intense when a fish is exposed to water from its home stream; and that, unlike controls, the imprinted fish react very strongly to the imprinting chemical.

The next step in the whole experiment will be to see how far from the home stream the fish can detect the imprinting odors and determine, if possible, just what the critical imprinting period is.

Hasler and his research team seem to have found the underwater guidepost which leads the salmon to its home stream once it has reached the home river, but other facets of the salmon riddle remain.

How do the fish navigate out in the open water of the ocean? And, once they hit the coast, how do they find the right river?

To find out, the Wisconsin team has spent many years tracking homing salmon—coho, pink sockeye, and chum—through fresh and salt water all over the Northern Hemisphere.

These tracking studies began in the early 1960's when the interdisciplinary research team perfected the use of a small, ultrasonic transmitter that could be placed in the stomach of a migrating fish or attached to its fin.

By listening to the transmitted signals, the trackers could follow a fish's movements from up to half a mile away. Since then, the biologists have worked closely with electrical engineers at the university to make these transmitters even more sophisticated. Some can now measure water temperature as well as indicate the location of the fish. Other, more complex transmitters, are also being developed.

Early salmon-tracking studies, supported by NSF, were done along the Pacific coast, but more recently, the scientists have turned their attention to Lake Michigan.

"In the lake, we are investigating near-shore orientation and movements," explains Ross Horrall, leader of the tracking team. "We are trying to determine what environmental cues the coho salmon uses when migrating close to shore."

Peter Johnsen and graduate student Jack Robinson, members of the tracking team, take fish that have already migrated to the Department of Natural Resources' fish trap on the Ahnapee River in Algoma, Wisconsin. They select a healthy female, take her on-board the University of Wisconsin's research vessel, *Aquarius*, and transport her about 30 miles south of the home stream. There, they tag the fish, attach the ultrasonic transmitter, and let her go.

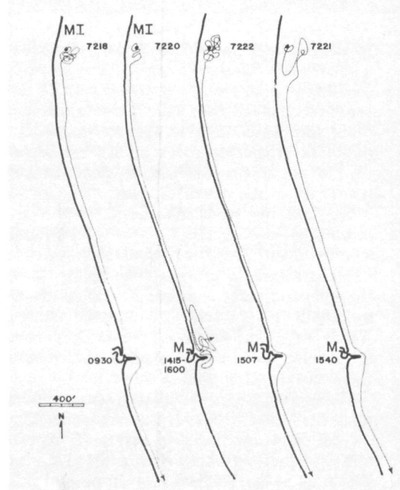
Then, using a hydrophone to monitor the underwater signals, they often spend 12 hours or more tracking the salmon on its journey northward, back toward Algoma.

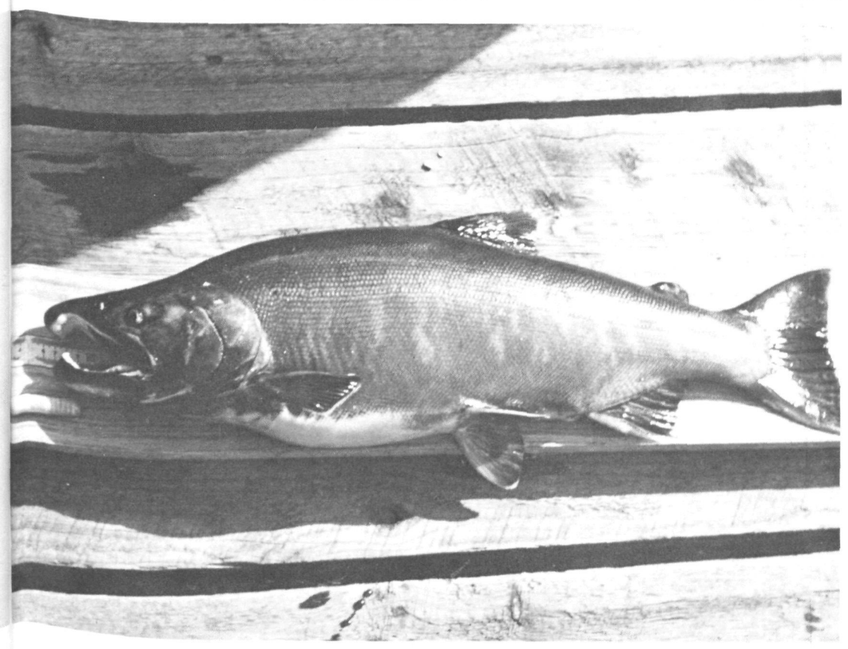
"We find that the fish swim in fairly straight paths and, when active, can maintain speeds of two miles per hour or more," says Horrall. "In the Lake Michigan tracks, nearly all the fish have headed north towards Algoma."

During the tracking operation the team is careful to record any environmental factors like sun and moon position, wave heights, and water temperature and currents at different depths—any factor that might be acting as a cue to guide the salmon.

There has been a lot of speculation about which cues the fish are using, particularly during migration across open water.

Wisconsin graduate student Jon Cooper measures a coho salmon's response to the imprinting chemical. (Right) An ultrasonic underwater transmitter, next to the salmon's head is used to track the fish (Below) Imprinted fish (MI) mill around the entrance to a stream containing the imprinting chemical, but swim past if the chemical is not present. Control fish pass without stopping, whether or not the chemical is present.





One idea, that they rely on the sun, is known as the sun-compass theory. Hasler and co-workers have shown that several species of fish, including salmon, have internal biological clocks that enable them to use the sun like a compass. This suggests that salmon might use the sun's position to orient themselves in the ocean.

But this can't be the only cue since fish are known to travel on cloudy days or even at night. The fish need other cues to navigate as well. Scientists have suggested that they may be using other celestial cues—gravity, the earth's magnetic field, water currents, or perhaps even some unique sensory system as yet unknown to man.

Actually, the fish are probably using a whole set of cues to navigate as do other animals, including man.

"We have a lot of ideas about what these cues are," explains Hasler, "but the hard part is devising a way to test them out on the fish."

Whatever the mechanism, the homing process appears subtle and complex—and it is fragile. The fish must rely on many factors to navigate, and man's activities can easily disrupt the process.

Wisconsin scientists have shown, for example, that home-stream fragrances are vitally important to the salmon's homeward journey. However, dumping pollutants into streams and rivers may alter these odors beyond recognition.

Lake Michigan trackers have also noticed another potential manmade disruption—the thermal plume. In tracking fish near a nuclear power plant, they noticed that the behavior of some of the migrating fish changed in the plume area.

"More research is needed to determine the influence of these plumes on the homing salmon," says Horrall, "but we are now working on two Sea Grant projects which are examining the effects of chemical pollution and thermal effluents on the behavior of migrating fish."

It appears that man will have to be more careful if he wants to preserve what is now essentially a free resource.

"The salmon are nature's gift to us," says Hasler. "We don't have to haul manure, feed them, or take care of them. As smolts, they go out to sea where they live and grow on the ocean's productivity, and then they deliver themselves free of charge to our backdoor for the catching and eating. To destroy this resource by building dams and polluting streams is something that we must search our conscience about."

All along, the important goal of the work at Wisconsin has been to help with the protection and management of this precious—and increasingly fragile—resource.

With their recent discoveries, the work of Hasler, Horrall, Madison, and a long line of scientists, students, and technicians seems to have paid off. But they are still at it, whittling away at the mystery of the homing salmon who hasn't yet given up all of his secrets to man. □

Great Swan Island – Hurricane Sentry in the Caribbean

BY EDWIN P. WEIGEL

When the 1973 hurricane season begins in June, and the giant pinwheel-shaped storms once again coil and drift westward across the Atlantic, the National Weather Service station on Great Swan Island will be playing a key role as usual, although under a new landlord.

The U.S. Government transferred sovereignty over the tiny island—two miles long by half a mile wide—to the Republic of Honduras last September 1, in a gesture of inter-American good will. Along with it went Little Swan Island—about one and a half miles by three-tenths of a mile—and Booby Cay, an islet about the size of a football gridiron. Only Great Swan Island is populated.

The treaty of transfer permits the United States to retain its weather station on Great Swan Island, which has been providing weather data for hurricane warnings since 1914—and for good reason.

According to Dr. Robert H. Simpson, Director of the National Hurricane Center at Miami, Florida: "Swan Island, located in the western Caribbean about 100 miles off the northeast coast of Honduras, is a key station in forecasting early- and late-season hurricanes that may affect Central America and the Gulf of Mexico." He adds:

"It is irreplaceable. Tropical cyclones frequently develop and begin to intensify south or southeast of Swan Island. By the time they get to the general vicinity of Swan, we at the Hurricane Center have to make up our minds whether these storms are likely to be strong enough to call for warnings for south Florida or the Florida Keys. In only 24 hours after passing a point near Swan, a storm will normally arrive at a place where it could produce gale- or hurricane-force winds in lower Florida. And 24 hours is the minimum warning interval we strive for with hurricanes, to allow plenty of time to evacuate coastal areas if necessary."

Dr. Simpson points out that the weather station on Swan Island is unique because it is in the middle of a "deep-ocean area not influenced by a continental land mass, and provides the only upper-air data between weather stations on British-owned Grand Cayman Island, to the northeast, and the Mexican city of Merida on the Yucatan peninsula, to the northwest.

"If you were to remove the station at Swan Island," says Dr. Simpson, "there would be a blank in the data on our weather maps much larger than a developing hurricane would be."

The five-man weather station provides observations for an area that is a sort of "hurricane alley." Arthur Youmans, Operations Chief for the Weather Service's Overseas Operations Division, says:

"Studies by the National Hurricane Research Project some years ago showed that the five-degree square of latitude and longitude in which Swan Island is located has experienced more tropical storms and hurricanes than any other five-degree square in the whole Caribbean area.

"If you look at a map, you will see that the weather stations at Swan Island and Grand Cayman just about bracket the path any storm must follow moving out of the Caribbean into the Gulf of Mexico. That makes those two stations very, very important—primarily for measurements of the upper air by instrumented balloons. These give us data about the steering currents influencing a hurricane's forward speed and direction.

"Such observations can be obtained in no other way."

It is for these and other reasons, explains Overseas Operations Chief Vaughn Rockney, that the Weather Service goes to all the trouble of maintaining a permanent station on such a small piece of real estate, even though considerable ingenuity, effort, and expense are sometimes involved.

"There are no wells or springs on the island; fresh water must be collected in cisterns from rainfall. We generate our own electric power, provide our own sewer system, even try to grow some of our food—mostly tropical fruits. Supplies are flown in by a chartered Cayman Airways DC-3 twice a month, or delivered at less-frequent intervals by small inter-island freighters.

"The usual tour of duty for Weather Service personnel of U.S. citizenry is about a year, with free transportation stateside every six months."

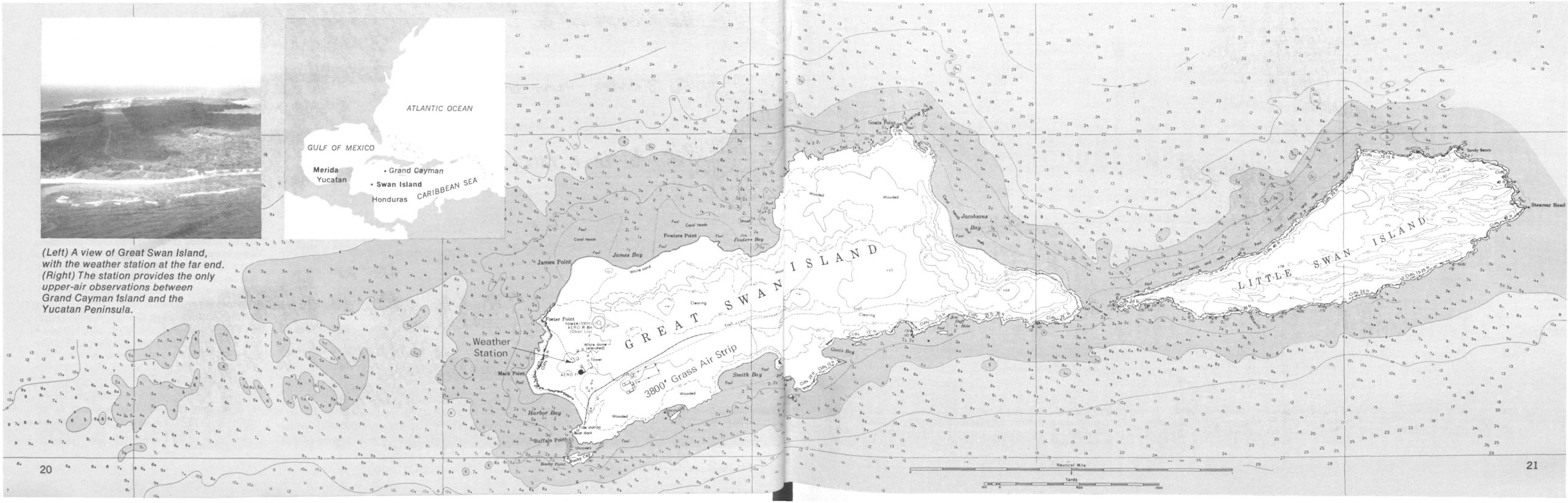
Rockney points out that Swan Island is not only important for hurricane forecasting. "Weather information it provides is an integral part of forecasts for flash floods, tornadoes, and winter storms that affect the U.S. It also gives us information about weather aloft affecting safe and efficient conduct of international air operations.

"Because of Swan Island's excellent exposure to ocean winds and the absence of atmospheric pollution, it is the site for many special measurements from time to time. It has one of the longest good records among National Weather Service stations of solar radiation. Currently it is the site of a special comparison of rain gages for the World Meteorological Organization.

"Another major function is to relay communications from other weather stations in the western Caribbean. It is connected by radioteletypewriter with Miami, and thence with the Federal Aviation Administration's switch in Kansas City, Mo. It has regular two-way radio communications with Colombia's San Andres Island, 120 miles off the coast of Nicaragua, and regularly relays this island's surface and upper-air observations to Miami and points overseas. In the event of failure of radioteletypewriter communications between Grand Cayman and Miami, Swan Island can relay Grand Cayman data to Miami. If all of these facilities were to fail in a tropical storm, Swan Island is equipped with standby generating power and radio facilities to provide an uninterrupted flow of weather data."

To give the NOAA family an idea of what Swan Island life is like, I accompanied Vaughn Rockney when he visited the island for six days late last summer to participate in the flag-transfer ceremony between U.S. and Honduras. Patrick Ianelli had just taken over as the new Official in Charge. On the staff at the time were Meteorological Technicians Bill Spencer, Raymond Agee, and Herbert Chadwick; and Electronic Technician Leo Garcia. Maintenance Representative Smoky (Carson B.) Walker and Supervisory Electronic Technician Bruce Hosmer were there on temporary assignments; and summer aides Paul Bigelow, Mark Allen, and Bill Saulnier were just winding up their seasons before going back to college. Two other summer aides—Gary Wagoner and Andy Novick—had left a week before our arrival.

Rockney and I began our trip to Swan Island from Miami via a Lacsa (Costa Rican) Airline twin-jet BAC-111, which took us 450 miles south across Cuba as far as Grand Cayman Island, in the British West Indies. There we stayed overnight and conferred with National Weather Service personnel who operate the Grand Cayman ra-



(Left) A view of Great Swan Island, with the weather station at the far end. (Right) The station provides the only upper-air observations between Grand Cayman Island and the Yucatan Peninsula.

(Left) Islanders and off-duty Weather Service student aides explore Little Swan Island, where the coralline rock is heavily pitted and fissured, and the walking is treacherous. (Right) The most common bird on the island is the brown booby. (Below) Rocky shoreline at the eastern end of Great Swan Island.

windsonde facility—headed by Official in Charge Frank Roulstone, who supervises a unique, all-woman staff.

Next morning we boarded a chartered Cayman Airways DC-3 for the 206-miles ride southwest to Swan Island. About two hours later, we skimmed down to land on the 3,800-foot grass airstrip and were greeted by station personnel.

That afternoon—August 31—we began preparations for the transfer-of-flags ceremony the following day. Rockney took charge of the Weather Service functions, coordinating with a State Department representative from Tegucigalpa, L. B. Sergeant, and Commanding Officer Richard L. Schreadley of the U.S. Navy Destroyer Escort BLAKELY, which had been dispatched to Swan Island to provide an honor guard for the ceremony. Also that afternoon, a U.S. Air Force C-123 transport flew in the first of two trucks from Panama to be used in giving visiting dignitaries a tour of the island after the ceremony—first dropping a paratrooper to reconnoiter the strip.

Among surprises for the paratrooper and other visitors was the discovery that the island has a rather large population of cattle, considering its size—about 100 head. At least one of these is an impressive bull.

The station was in elegant shape to receive visitors—buildings agleam with fresh paint, grass neatly trimmed, diesel-electric generator immaculately rubbed down, instruments and records all in place.

The day of the ceremony dawned bright, hot, and humid—hard on dignitaries in business suits or formal military dress. The C-123 returned with another truck. A Honduran DC-3 arrived with a planeload of officials, and U.S. Ambassador to Honduras Hewson A. Ryan appeared in a DC-3 bearing four stars and the U.S. Seal. A little later the *Ejecutivo* aircraft of then-President of Honduras Ramon Ernesto Cruz touched down and taxied up to the waiting party, where *El Presidente* was officially greeted by Ambassador Ryan as he stepped from the plane.

After an inspection by President Cruz of the U.S. Navy honor guard, and a short ride in a jeeplike vehicle to the ceremonial site, the U.S. flag was hauled down for the last time, to the roll of a drum, and the Honduran flag was hoisted in its place. Rockney escorted President Cruz on a tour of the station, and a ceremonial weather balloon was released. Then the visiting dignitaries were taken out to the BLAKELY, offshore, for an official luncheon. Afterward, back on the island, there was a quick tour in the trucks and the ceremony was over. Swan Island soon returned to a more leisurely pace.

The next day was the beginning of Labor Day weekend, so Rockney and I had a good chance to sample the island's atmosphere under holiday circumstances—get to know the islanders and their families, enjoy some of the unusual recreation possible on a tropical island.

A big plus for outdoor sportsmen is the fishing—it's tremendous. Guided by islander Spencer Bennett and some of his companions, we made several trips trolling for grouper, jack, yellowfin, barracuda, and other gamefish in the station's 40-horsepower outboard motorboat. Rockney caught a grouper we estimated at 50 pounds. We trolled fast, using large silver spoons attached by wire leaders. Strikes came almost as fast as we could reel the fish in. Not infrequently, sharks took all but the heads. The waters are almost unbelievably clear, and we could see the action distinctly many feet down.

One trip was primarily for spiny lobsters, which abound in small grottoes among coral heads on the sea floor. Islanders Ronnie Moore and Van Phillips—using spear guns, snorkels, face masks, and flippers—dove repeatedly to impale these big delicacies. Most weighed three to four pounds. Bennett explained the technique for finding them: First determine which holes are productive, then come back on successive trips. A lobster removed on one trip will be replaced by another next time out.

Cooked and dipped in melted butter, these oversized crayfish are delicious.

If you're an amateur naturalist, Swan Island can keep you spellbound day after day. Most spectacular of its fauna are iguanas four to five feet long, which when surprised on a cliff leap unhesitatingly into the sea and swim away like miniature alligators. There are smaller lizards, too—one a rare variety related to the familiar but misnamed "chameleon" of southeastern U.S., said to be unique to Swan Island. On Little Swan is a blind wormsnake no larger than a knitting needle.

There are no native mammals on the islands now—only cattle, a couple of horses, a few domestic cats gone wild, rats and mice, and a pet dog. In years past, there were on Little Swan many brownish-gray rodents called hutias, said to resemble "lean guinea pigs." Hurricane Janet is believed to have wiped them out in 1955. They were of great interest to mammalogists.

Birds are everywhere. Among the commonest is the brown booby, a seabird with a four-foot wingspan. Boobies were formerly present in enormous numbers. They were responsible for large deposits of guano mined from the island in the late 1800's. The boobies lay their eggs on cliffs bordering the islands, and live on small fish they catch by diving into the water.

Pirating and preying on the boobies are man-o'-war birds, also called frigate birds, which drift effortlessly in the thermals. They look like huge, fork-tailed swallows with seven-foot wingspans. They mercilessly rob the boobies of fish by zooming and striking at them repeatedly until the boobies drop their catch, which the man-o'-wars must pluck from the air, since they cannot swim. The man-o'-wars also cruise the shorelines looking for unattended booby chicks, which they seize and carry away.

Other residents are cattle egrets, which probably arrived with the livestock. Foraging with the egrets near the cattle are smooth-billed anis, weak-flying birds which look like hybrid blackbird-parrots, with dark plumage and thick, down-curved beaks. They flutter about in small, noisy flocks. White-crowned pigeons are abundant—larger than common pigeons and much more wary. The jungle trees echo with their throaty "hoo hoo-hoo."

There were also several species of swallows, countless southbound kingbirds, nighthawks, a quartet of teal taking refuge in a tiny pond, sandpipers, a waterthrush, a black and white warbler, a night heron, a green heron. Many of these were migrants passing through. One wonders how they find such a place—100 miles from any other land.

Spencer Bennett, a Honduran who is the Weather Service's chief wage-board employee on the island, introduced Rockney and me to its plants. Bennett is a man of many skills. Besides taking care of the station's diesel-electric generator, he also is an accomplished fisherman, scuba diver, "rancher," botanist, and plant culturist. In small plots fenced off from the browsing cattle, he is experimenting with various tropical fruits and other edible plants. Included are several varieties of bananas, plantain, cassava, canteloupe, watermelon, pumpkin, sweet potato, yam, papaya, pineapple, grapefruit, and sugar cane, among others. His goal is to learn which ones fare best on a small tropical island with salt spray close on all sides.

On our guided tour he pointed out many wild species—sea grape, strangler fig, bastard mahogany, buttonwood, satinwood, castor beans, cactus, palmettos, thatch palm, guinea grass, a species of birch, almond—and a tree that produces blisters on your skin if you stand beneath its dripping foliage during rain.

There still are a number of coconut palms on the island, left over from the time when United Fruit Company harvested copra there many years ago—but nothing like the 15,000-tree plantation that existed before Hurricane Janet.

The Swan Islands are also notable for shells and coral, for those whose tastes run to marine collections. Large conches—with whose empty shells you can "listen to the ocean roar"—are abundant. Big hermit crabs scuttle about in thickly wooded sections high above the water's edge, rustling mysteriously in the fallen leaves. Chitons—suggestive of fossil trilobites—are clamped tightly to tidal rocks. Washed-up brain coral, with its delicate tracery, is easy to find on the beaches. Sea turtles—green, hawksbill, and loggerhead—lay their eggs in the sand.

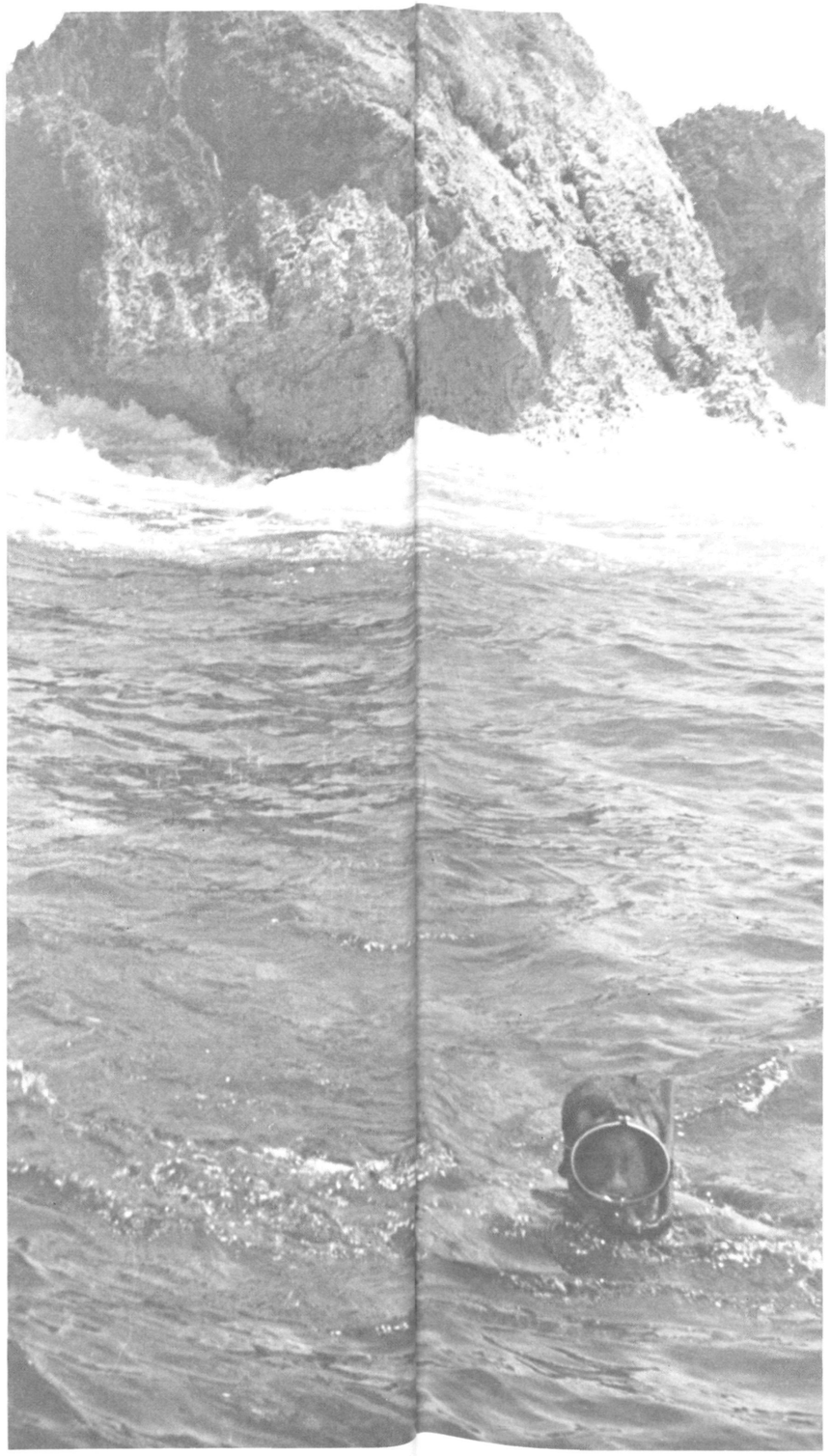
There are lots of butterflies, but few biting or stinging insects.

Among kinds of fish, besides those we caught, are butterfish, lookdowns, tuna, mackerel, parrotfish, puffers, red snappers, Bermuda chub, and white tip and nurse sharks. The list could go on and on.

Climate of the Swan Islands—according to the Environmental Data Service—"closely approximates that of adjacent tropical seas, since their land mass is too small to cause significant modification of the weather."

Temperature changes are small. Year in

Fishing provides recreation—and food —for Weather Service staffers and residents on Great Swan Island. Vincent Chin (above) holds a spiny lobster speared underwater by islander Ronnie Moore, (far right). (Below) Vaughn Rockney, Chief of the Weather Service's Overseas Operations Division displays a catch. (Right) Spencer Bennett, Weather Service wage-board employee, with a yellowtail.



and year out, daytime highs average in the 80's; overnight lows in the 70's. Highest on record is 92 degrees, lowest 64. August is the hottest month, with an average monthly mean of 83 degrees; January the coolest, with 78. But there is considerable variation in rainfall—a dry season from January to May, and a wet season from June to December. Annual rainfall has varied from about 37 inches to 80, with an average of 50. Monthly totals over 30 years have averaged from 0.77 inches in April, the driest month, to 9.89 in October, the wettest, illustrating the pronounced extremes of the yearly cycle. During some dry seasons, it has been necessary to ration fresh water.

According to the Swan Island climatological summary: "Neither hail nor heavy fog has been recorded. Thunderstorms are likely to occur five to ten days per month from June through October, but they are much less frequent in other months. Tropical storms often form in the western Caribbean early and late in the hurricane season. . . . but destructive winds have been infrequent at Swan Island station. . . . Hurricane winds on October 14, 1916, estimated at 100 miles per hour, destroyed three out of four of the 300-foot wireless towers of the Tropical Radio Company, and blew down hundreds of coconut trees. The winds of Hurricane Janet on September 27, 1955, estimated in excess of 150 miles per hour, destroyed or heavily damaged buildings with the exception of a concrete seismograph building, and destroyed about 90 percent of the coconut trees."

The "seismo" building still stands ready to serve as an emergency shelter for island residents if another hurricane hits. It is stocked with canned goods and has a radio with emergency generator.

The trade-wind dominates the air flow across the island, blowing steadily from the east at about 12 knots. The warm breezes combined with high humidity can be enervating. For relief, the Weather Service has provided large ceiling fans in each bedroom and fully air-conditioned the mess hall and recreation center. Powerful light bulbs burn continuously in closets to prevent mildew.

Probably the most fascinating aspects of Swan Island are its permanent inhabitants and its history. When this was written, five local families of Honduran and Caymanian origin were living there, plus Vincent Chin, the Chinese cook, and several members of his family. The islanders live in small frame houses just outside the 35-acre Weather Service compound. During our visit, all of the breadwinners were on the Weather Service payroll. Their names are not, as you might suspect, indicative of Spain, but rather of England or Ireland. They are, in addition to Spencer Bennett, Ronnie (Randolph) Moore, Charles Van Phillips, Norman Smith, and Horris Kelly. Each is married, with one or more children. There were 24 islanders of all ages on hand during the flag ceremony.

The island patriarch for many years was Donald Glidden, who retired to Grand Cayman not long ago at age 80. According to Richard Severo, a New York Times reporter who interviewed him in November 1971, the white-haired, blue-eyed "Captain Don" first came to Swan Island from Grand Cayman in 1927. He had three wives, two of whom died; eight children; about 30 grandchildren—"he couldn't remember exactly"—and at least eight great-grandchildren. Many of the islanders are related to him.

Captain Don told reporter Severo he felt he owed allegiance not to Britain, the U.S., or Honduras, but to Sumner Smith, living on a 300-acre farm in Lincoln, Massachusetts. Mr. Smith, interviewed later by Severo, insisted he had owned Great Swan Island until the U.S. Government took it away from him in 1970 "without even a thank you." He explained that a company in which his family was part owner, the Swan Island Commercial Company, had taken title to the island from a Captain Alonzo Adams, who had sailed there from Mobile, Ala., in 1893 and staked a claim.

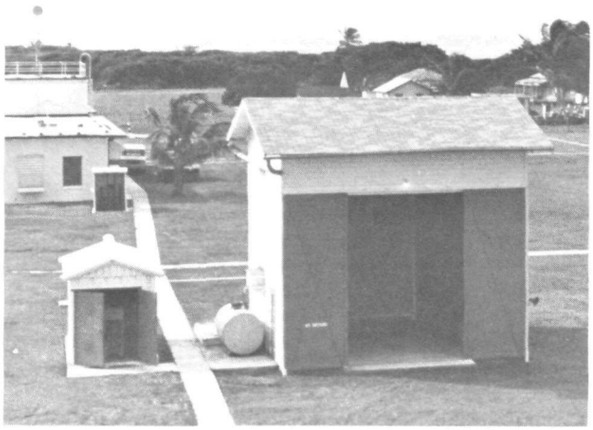
In the early 1900's, the Swan Island Commercial Company leased part of Great Swan Island to the United Fruit Company, which planted thousands of coconut palms. A stone marker for this property still stands. It reads: "Boundary of property leased to United Fruit Company, Dec. 10, 1912." The coconut enterprise was not too profitable, however, and United Fruit pulled out after a time. The company provided weather data for hurricane warnings from its wireless station, July through November, from 1928 until 1932.

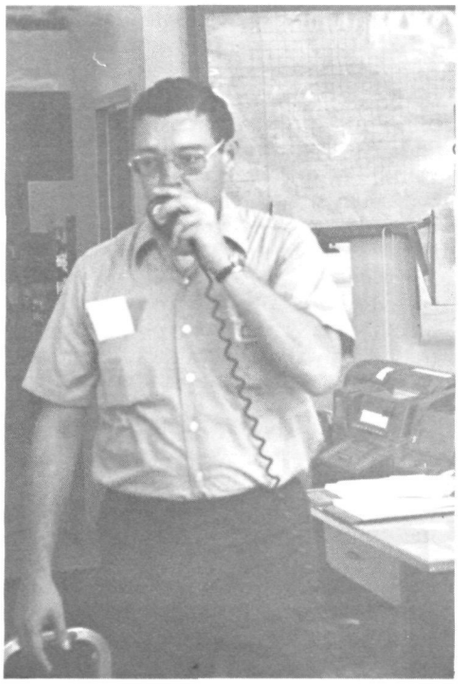
The U.S. Weather Bureau established a part-time station on Swan Island in 1938, manned at first only during the hurricane season. This became an all-year operation early in the 1940's. In the late 1940's, after World War II, the U.S. Agriculture Department experimented a couple of years using Great Swan as a quarantine station for Latin-American cattle destined for the U.S. The project was abandoned in 1949, but some of the old sheds still exist.

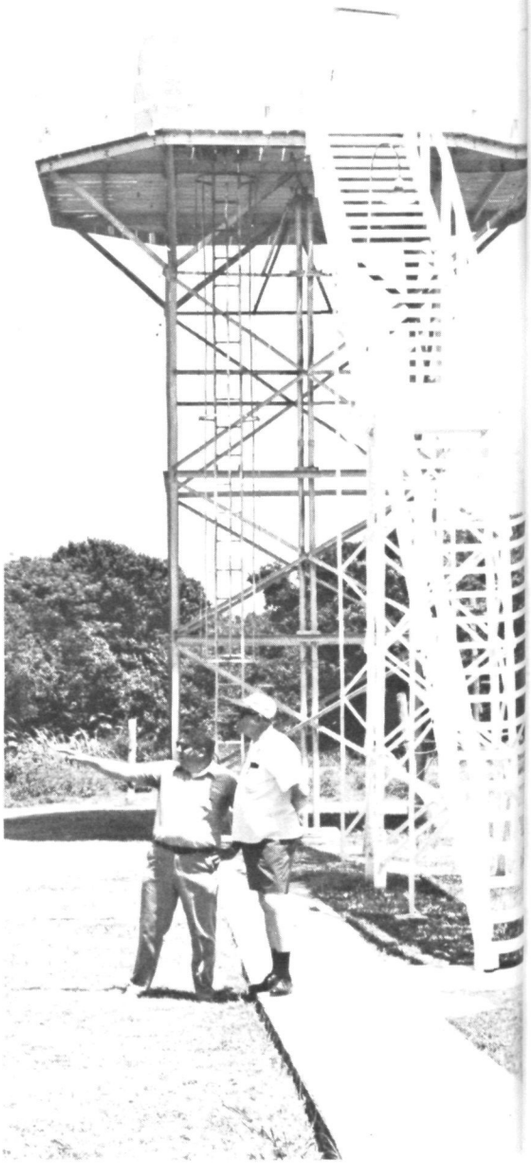
An aircraft radio-navigation beacon was installed on Great Swan in 1946 for guidance of Caribbean air traffic. It was operated by the Federal Aviation Administration until October 31, 1971, when the FAA pulled out, leaving only the Weather Service to represent U.S. Government interests on the island.

A special event in 1960 was a visit to the island, March 12 through 19, by the U.S. Coast and Geodetic Survey (now National Ocean Survey) ship EXPLORER, en route from Seattle to Norfolk. On March 15, Captain Edmund L. Jones took the official 1960 census of Swan Island, consisting of 28 people—19 Caymanians, three Hondurans, and six U.S. citizens attached either to the Weather Bureau or the FAA radio station.

A somewhat hazy period of the island's history began after Fidel Castro took over Cuba. A 50,000-watt radio station was set up on Swan Island and began broadcasting







programs in Spanish in June 1960. It was reported to be owned by a New York firm called Gibraltar Steamship Company, which operated no steamships. "Radio Swan" was denounced by Castro as being a propaganda voice for expatriate Cubans. After the abortive Bay of Pigs invasion in 1961, the station's name was changed to "Radio America," and its headquarters moved to Miami. Later, it was discontinued.

Shortly after this episode, negotiations were begun by the Kennedy Administration with Honduras aimed at settling a sovereignty dispute over the Swan Islands. The Honduran Government had first laid claim to them in the early 1920's, but did not press its claim until the 1960's. Hondurans maintained that, when Columbus made his fourth voyage to the New World in search of a passage to the East Indies, he stopped at the Swan Islands in 1502, reportedly to pick up wood. This, they said, made the islands a part of the Spanish colonial empire, to which Honduras was the rightful heir.

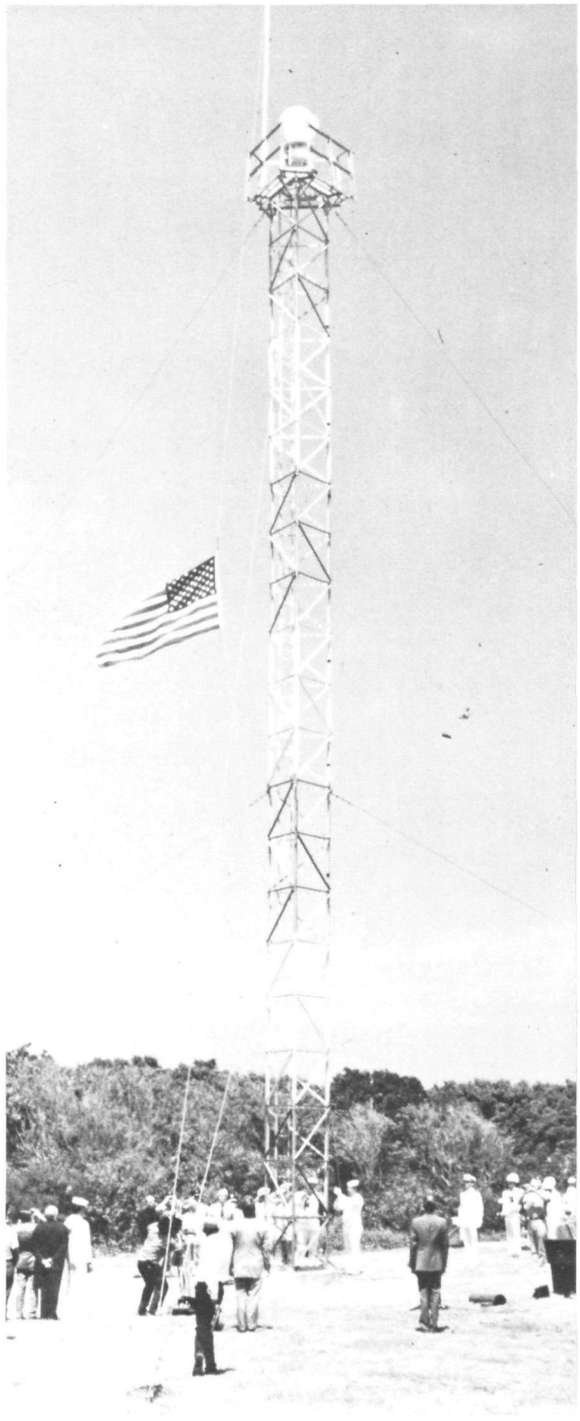
In 1963, the U.S.-Honduran negotiations were broken off as a result of Honduran governmental changes. They were re-opened by order of President Nixon in 1969. Sumner Smith's claim to the islands was given careful scrutiny by U.S. attorneys who disclosed a prior U.S. claim they said invalidated his. This claim was based on the Guano Act of 1856, which permitted U.S. citizens discovering guano on unclaimed islands to apply for certificates entitling them to collect the stuff and sell it as fertilizer. The Act also allowed the U.S. to claim the islands as U.S. property, which Secretary of State William Seward did for the Swan Islands in 1863. The Government said an American, George V. White, landed on the islands in 1857, claiming them for the U.S., and that a commercial company began exporting guano in 1858.

Sumner Smith tried to press his claim in a court suit, but a Federal judge in 1970 ruled for the United States, clearing the way for the transfer.

The treaty with Honduras calls for continued operation by the U.S. of its weather station on Great Swan Island, and cooperative operation of the aircraft radio beacon. It was signed November 22, 1971, in Honduras. The treaty was ratified by the U.S.

(Opposite page) A view of the weather station (upper left), meteorological technician Bill Spencer (top center) making radio call, barracks (lower left) for station personnel, and (right) official in charge Patrick Ianelli and Vaughn Rockney by the rawinsonde tracking facility.

(Above) U.S. Ambassador to Honduras Hewson A. Ryan, fifth from left, and official party await the arrival of the Honduran President's plane for ceremonies marking the transfer of sovereignty over the island to Honduras. (Below) The dignitaries were transported in Spencer Bennett's Mini-Moke. (Right) The U.S. flag is lowered from the Swan Island flagstaff.



Senate on June 13, 1972, and signed by the President shortly thereafter. Culmination was the flag-transfer ceremony September 1.

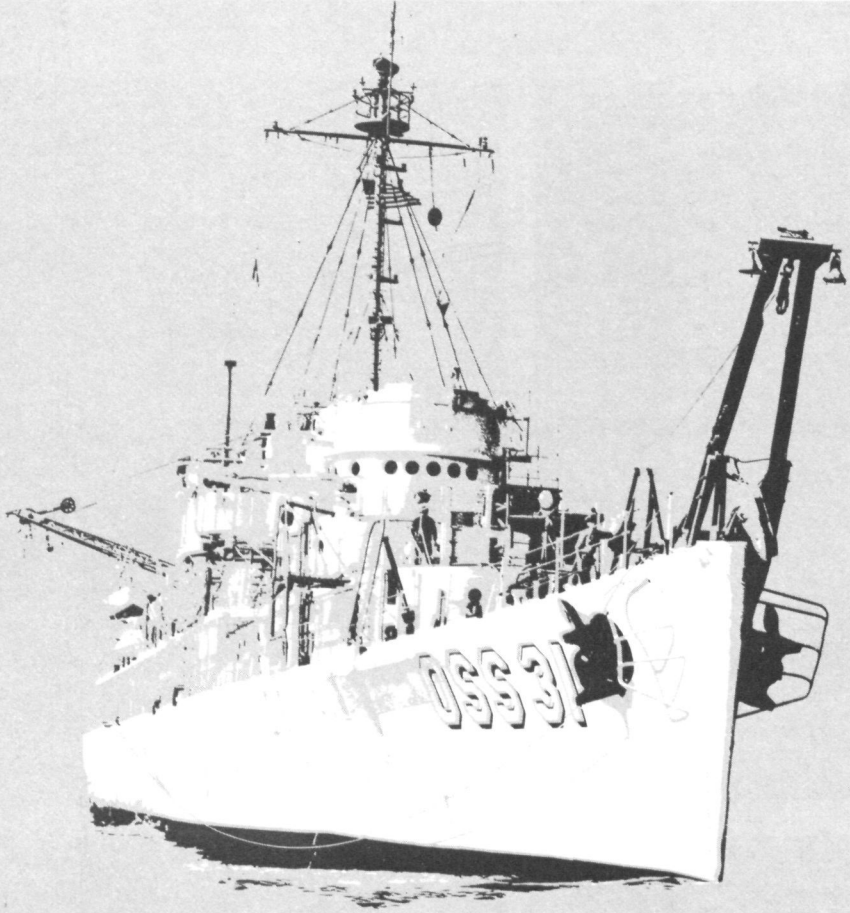
Swan Island, like so many Caribbean islands, is said to have been a bastion for buccaneers early in its history. There is some historical documentation to indicate the island is named after a British Captain Swan, master of the CYGNET, who had been sent to the Caribbean by London merchants with a cargo to sell. Historians say that in 1680 Captain Swan's ship was attacked by pirates who forced him to join them. It is said Captain Swan may then have become one of the buccaneers who dominated the area. A 1939 write-up of the island by the U.S. Navy Hydrographic Office tells of pirate defensive breastworks still visible on the western part of Great Swan.

In spite of its lively history, U.S. mainlanders assigned to the Swan Islands weather station are inclined to find it monotonous —no television, no newspapers, no theaters, no shops or supermarkets, only a few people, little noise, none of the bustling clangor and traffic of modern civilization, and no place to go beyond a mile or so.

To add to the attractiveness of assignment there, the Overseas Operations Division has taken special pains to provide conveniences and diversions: plenty of good food, large-capacity automatic washer and dryer for personal clothing, free transportation to and from the U.S. mainland after six months, a special housing unit for two-week visits by wives and children, full-length movies in the recreation center, a high-quality stereo tape player, well-stocked library, and access to a seaworthy outboard motorboat for fishing and skin diving.

For people inclined to be thrifty, it's a great place to save money, because there's no place to spend it. And if you're fascinated by the natural world—tropical plants, coral, birds, reptiles, fish, crabs, lobsters, mollusks and other marine life, you can stay engrossed with Swan Island for months.

For a while, at least, it will remain one of nature's relatively unspoiled hideaways. Perhaps this was the inspiration for the sign that greets visitors at the dock—"Swan Island—Last of the Caribbean Paradises." □



The Noisy Deep

Chinese tunnelers? A lost continent? Humming oysters? What was the source of the strange undersea sounds that interrupted a charting survey 38 years ago?

BY RAYMOND WILCOVE

It happened almost 38 years ago, some 60 to 100 miles off the California coast. Unexplained noises were interfering with the mapping of the ocean bottom by the U.S. Coast and Geodetic Survey Ship PIONEER.

According to an Associated Press report from San Pedro, "Weird, ghostly noises, emanating from the deep in the Pacific Ocean between San Clemente and Oceanside, have disrupted the concluding phases of the United States Coast and Geodetic Survey's charting expedition along the Pacific Coast."

A painstaking investigation by the commanding officer of the PIONEER, Captain O. W. Swainson (then a lieutenant commander), failed to turn up the cause of the noises on the ship's radiophones, although many suggestions as to their nature poured in from the United States and abroad.

Interest in the noises was revived by a letter to NOAA's National Ocean Survey, successor to the Coast and Geodetic Survey, from a California editor who was queried about the 1935 article by a reader. What was the source of the noise, inquired the editor of the San Diego Tribune.

To this date, no one has provided a convincing answer to the mystery, although many "solutions" have been proffered. Strange noises have also been reported from time to time in the Gulf of Mexico, off North Carolina, and in Alaskan waters.

The noises have been variously interpreted as having been caused by:

—Chinese digging a tunnel to California beneath the Pacific Ocean.

—Ocean currents sloshing through underground channels and conduits of the sunken continent of Lemuria.

—Oysters humming in their beds.

—The rubbing of sunken ships, rocks, and other materials in subterranean straits connecting the "outer and inner oceans" in an "Inner World" beneath the sea.

—Fish grunting.

—The generation of Piezoelectricity by sand crystals on the beach.

—Oil wells.

—Waves breaking against the shore.

—Defective machinery aboard a ship.

One of the more interesting explanations for the noises was advanced by a Burbank, Calif., woman. She said they might be caused by workmen building a tunnel beneath the Pacific Ocean from China to California.

Her late husband, whom she described as "a very peculiar man, highly educated" and well traveled in the United States and Europe, had predicted that "some day the Chinese will undertake to invade this country by a tunnel underneath the ocean, landing in California." A few days later, she continued, he dreamed he saw "hundreds of Chinese pouring out of a tunnel entrance . . . armed with U.S. arms and . . . bleached white almost from their confinement" in the tunnel.

A man in Moose Jaw, Saskatchewan, Canada, said the noises might be caused by ocean currents flowing through "water conduits and underground water systems on the sunken continent of Lemuria."

"It is a well-known fact," he stated, "that underground rivers or underground water systems, such as conduits, tend to set up electrical disturbances and vibrations which can be registered on electrical instruments, such as radiophones."

When the sun nearly reaches the zenith, he added, it may set up electrical disturbances "which might cause a reaction of ocean current" in the underground channels.

The Canadian added that the currents might cause the noises while sloshing around the remnants of the sunken continent of Lemuria.

"In view of the fact that geological surveys have unearthed previously evidence . . . substantiating the theories of a former continent that has submerged beneath the Pacific, namely the continent of Lemuria," he continued, "I would deduce the fact that owing to the high state of civilization prevalent in this continent before its submerging, that there is the possibility of there being water conduits and underground water systems beneath the floor of the Pacific."

Belief that another continent once existed in the Pacific and sank beneath the sea thousands of years ago has persisted for many years. Like the fabled Atlantis which sank beneath the Atlantic Ocean, this continent also was populated by an advanced civilization, and writers have speculated that the Hawaiian Islands and Madagascar are remnants of the lost continent.

The continent is variously called Lemuria or Mu. According to the *Encyclopaedia Britannica,* "Madagascar belonged to a continent called Lemuria (from the lemurs which still inhabit the island) and stretched as far as India."

Others have speculated that the Aztecs of Mexico, the Mayans of Yucatan, and the Incas of Peru, all of whom had advanced civilizations when Europeans explored the Western Hemisphere, represented colonies of the lost continent.

According to one writer, Lemuria had a population of 64 million and sank beneath the sea approximately 15,000 years ago.

A Glendale, Arizona, man advised Swainson that the unexplained noises in the hydrophones were due to the movement of sunken ships, rocks, and other debris in "subterranean straits" which connected the "outer and inner oceans" in an "Inner World."

He submitted a diagram of the subterranean straits in which a dotted line represented the center of gravity. "There would be loose matter," he wrote Swainson, "in the shape of rocks, sunken ships, and anything too heavy to be carried up on the floor of the ocean. As the tides go by, then settle back to the center of gravity and bob back and forth until they come to rest on the center of gravity, they would cause these noises banging on the shores of the straits."

Along with the diagram were directions for finding the subterrannean straits. "By taking note of the tides," he stated, "you can determine the longitude on which the straits must be, then follow the longitude, searching the floor of the ocean until it is found."

The Arizonan followed up his letter to Swainson with another to Secretary of State Cordell Hull in which he advised the Cabinet officer that "I would like to have the administration give Lt. Cmdr. C. W. Swainson orders to search for the cause of these unexplained noises."

The State Department forwarded the letter to the Department of Commerce, which had jurisdiction over the Coast and Geodetic Survey. "The Secretary of State presents his compliments to the Honorable the Secretary of Commerce," the department wrote, "for such action as may be deemed appropriate. . . ."

In due course, the correspondence made its way to Swainson who informed the Arizonan that the area where the noises were heard was no longer being surveyed, adding that "no absolute explanation was discovered to account for the interference."

But this did not end the matter. Upon receiving Swainson's reply, the Arizonan communicated with President Franklin D. Roosevelt. In a neatly typed letter, he noted that he was trying to get the Navy Department to make a systematic search for the subterranean straits. He suggested also that some of the 12 million people then unemployed during the great depression be used to dig a tunnel "to the Inner World.

"Do not let it be said that a thousand years hence," he admonished the President, "when some mine gets below the center of gravity and rocks fall outward that the Inner World might have been discovered long ago if the educated people of America had not turned this theory down."

The belief that the mysterious noises might be due to someone or something in another world below the sea was not restricted to the man from Arizona. From Sacramento, Calif., came the suggestion that the "tappings" heard on the hydrophones might be explained in a book published originally in 1826 and reprinted in the 20th century.

"If you will get a copy of that famous book, Etidorpha," he wrote Swainson, "you will find more information in regard to the interior of the earth and its outer expression than in all other books ever printed. It might explain the 'tappings' that have interested you. . . . Written in 1826, it has been given to the world again. Such men as you can appreciate it." The book was written by John Uri Lloyd, said Swainson's correspondent, and came replete with drawings.

Still another suggestion on the origin of the noises came from a man in Brooklyn, N.Y., who wrote, "I have a newspaper clipping of about seven years ago relating the similar experience of an expedition, and it states that the interference was traced to a vast bed of oysters."

The oysters made "a humming sound of a tuneful nature, like a person humming a tune."

The Associated Press had apparently heard about the oyster theory. In reporting on the explanations proffered regarding the mysterious noises, it noted that one letter said "it might be oysters which, grouped in vast beds on the sea floor, set up the noises while feeding, and possibly discussing between themselves the current price for pearls."

From La Jolla, Calif., came the warning that the noises were the precursor of an earthquake. The noises were occasioned by "strain" on the earth, wrote Swainson's correspondent, caused by the influence of the sun, moon, and planets. When they reached a peak, he continued, there would be an earthquake, and he predicted it would occur on or before the morning of August 26, 1935. An earthquake was felt in King County and Priest Valley, Calif., August 9, and another in Escondido August 18. Neither caused any damage. From the astrological standpoint, he asserted, the noises indicated "fires, accidents, and trouble with law enforcement officers." All in all, they were cause for considerable worry.

They were also of considerable interest to the *Literary Digest*, a prominent magazine in the 1930's. Science Editor G. Edward Pendray asked the Coast and Geodetic Survey if it could explain "what this is about" and whether there had been any previous experience with similar noises.

Raymond S. Patton, Director of the Coast and Geodetic Survey, advised the *Literary Digest* that it was difficult to say what caused the noises.

"Noises similar to these have been heard in the Gulf of Mexico" by another C&GS ship, wrote Patton, "and the noise seemed to have a definite periodicity following a 24-hour cycle daily, rather than with any reference to tides, moon, or anything of that sort.

"Several years ago," he continued, "noises were heard on the North Carolina coast which were rather definitely attributable to a fish called the grunt fish. These noises were of rather a low pitch and not a clicking noise such as has been described by Lieutenant Commander Swainson. The noises observed in the Gulf of Mexico were more of a hissing sound than the low pitch noises heard on the Atlantic coast."

Patton said the unexplained noises in the Pacific might be produced by fish or some form of marine growth and suggested it might warrant an "intensive study" by some oceanographic institution.

Still other possible explanations offered by the Coast and Geodetic Survey included "the generation of Piezoelectricity by sand crystals on the beach due to wave action," oil wells along the shore (generally discounted because the oil pumps operated continuously while the noises were periodic), and waves breaking against the shore. Swainson disproved the latter suggestion, pointing out that when the weather was calm, reducing the surf to a mere ripple, the noises continued unabated.

Captain Roland D. Horne, a retired NOAA commissioned officer, said that when he served aboard ship "we frequently picked up strange sounds on the hydrophones set up for our sound ranging work, some of it attributed to noises emitted by curious fish and crustaceans."

Rear Admiral William M. Gibson, another NOAA retired officer, who also served aboard the PIONEER, recalling the almost four-decades-old incident, commented that "we often were plagued by such noises in the early days of the development of sound and radio ranging. The first reaction was usually to find some machinery on the ship that might be responsible. However, Captain Swainson would have checked that out thoroughly first of all."

Gibson, a hydrographic and geodetic engineer, also remembered a similar incident which occurred about six years later while aboard the PIONEER in southeastern Alaskan waters. But Gibson said the ship thought the noises were caused by a bent pitometer in the hull of the fathometer transceiver.

Swainson, in his annual report at the conclusion of the 1935 season, stated that "considerable interference was experienced with the hydrophone near Oceanside by unaccountable bangs. . . . The source of the trouble was never found, but a strong suspicion is entertained that they were associated with static and oil wells. Most of the bangs apaprently were caused by vertical vibrations."

However, the noises were heard only between 11 a.m. and around 4 p.m., whereas the oil wells operated continuously. The noise began with faint clicks, increasing to a continuous roar by late afternoon, forcing the ship to quit work.

Paul C. Whitney, then Acting Director of the Coast and Geodetic Survey, wrote in 1935 that "no definite reason for the 'noises' has yet been established by the officers of the PIONEER."

The PIONEER, her skipper, and many of her officers and crew are now gone. To date, there has been no adequate explanation, only conjecture, for the "weird, ghostly noises" which disturbed the operations of the USC&GSS PIONEER almost four decades ago. □

SEE IT WITH YOUR OWN EYES

Nothing to read? Seen the movie? Atmospheric events offer diversion for the observant air traveler.

BY RICHARD H. GILLULY

In an age of highly sophisticated scientific instruments, air travelers may take for granted one of the best remote sensors ever carried aloft: the human eye. According to a scientist at the Environmental Research Laboratories, there is much in the atmosphere that meets the eye if the airborne observer can interpret what he sees outside his window.

Dr. Freeman F. Hall, Jr., says that viewing some of the colorful phenomena of the atmosphere can be both entertaining and instructive, and that many of these events can easily be photographed.

Dr. Hall, who leads the atmospheric acoustics program in the Wave Propagation Laboratory, is himself a developer of new ways of observing atmospheric events through their interactions with various forms of energy. His group's acoustic sounder is being used experimentally to monitor inversions and other pollution-related atmospheric features in urban areas.

The retina of the human eye is a highly developed sensor of light in the range of wavelengths we term "visible" for that reason. And, says Dr. Hall, a number of events occur in the atmosphere which alter the visible radiation of the sun. An airplane is an excellent "platform" for viewing these events because of the perspective it creates. But modern, 600-mile-per-hour aircraft sometimes have quite an impact on the atmospheric environment themselves and aircraft-caused atmospheric changes can also be viewed.

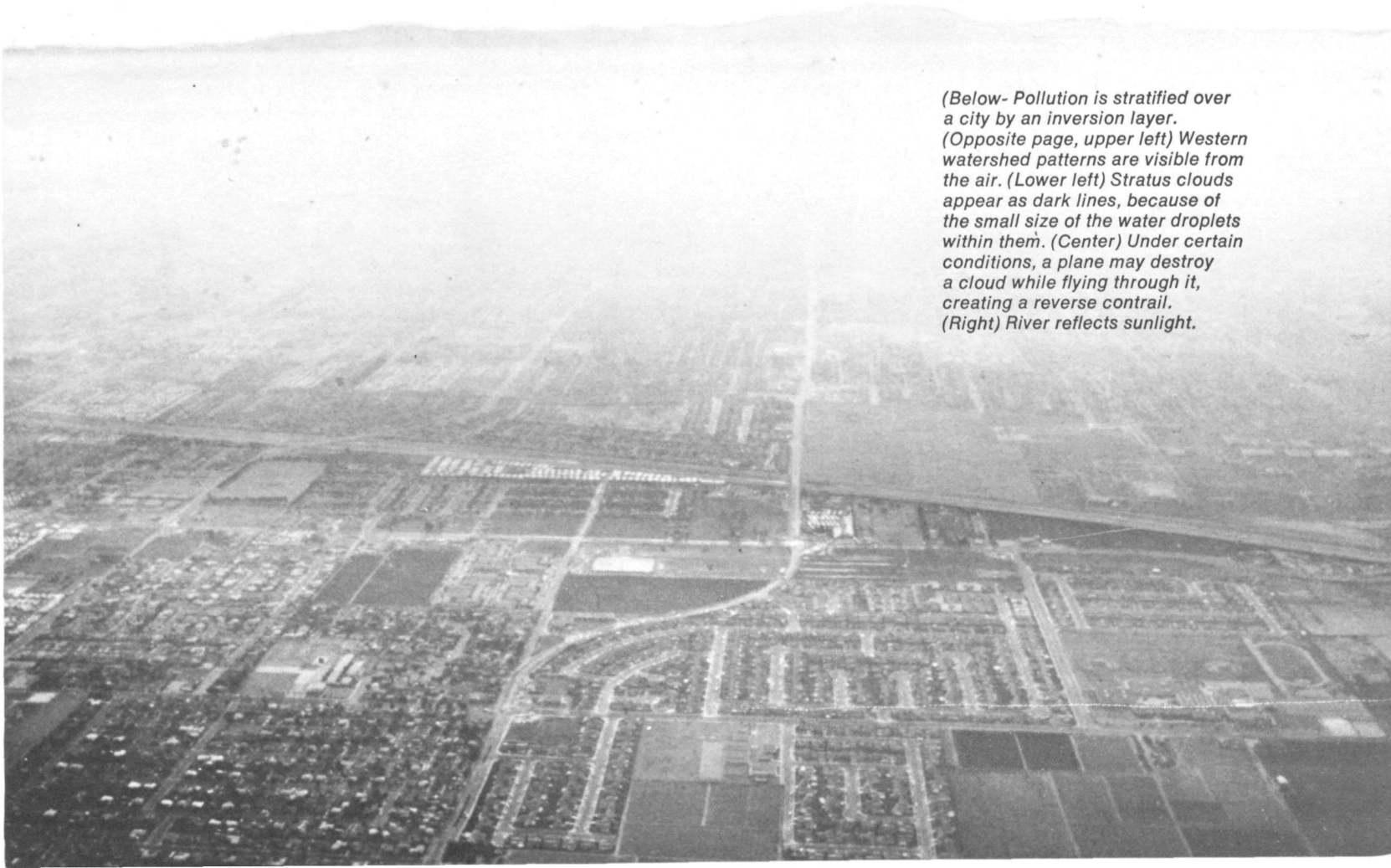
One of these aircraft-caused events can sometimes be seen at takeoff, especially if there is a background of haze, thin clouds, or ocean. The speed of the aircraft causes a change in the index of refraction of the air surrounding the airplane. This phenomenon results in a visible brighter area ahead of the aircraft on the side opposite from the sun, and viewers on that side can sometimes distinguish the luminance pattern from the normal shadow of the aircraft —especially if viewed against the uniform background of the ocean's surface.

"Many of the optical events," says Dr. Hall, "originate from the scattering, refraction, and/or reflection of sunlight by haze or clouds."

Scattering by haze—either natural or manmade, the latter near big cities—can also best be viewed at lower altitudes shortly after takeoff. The amount of scattering depends greatly on the angle of the sun with relation to the viewer. The maximum scattering of light—resulting in a diffuse luminance —occurs with the observer looking directly toward the sun. Luminance falls off then with a minimum at about 110 degrees from the sun, but picks up again with a new, but lesser, peak at 180 degrees.

After level flight is achieved "scattering by water droplets and ice crystals of clouds also allows the air traveler some interesting observations," says Dr. Hall.

Particularly interesting are the differences between appearance of clouds caused by different-sized water droplets or ice crystals in the clouds. Fluffy white cumulus clouds contrast sharply with the much darker lay-



(Below- Pollution is stratified over a city by an inversion layer. (Opposite page, upper left) Western watershed patterns are visible from the air. (Lower left) Stratus clouds appear as dark lines, because of the small size of the water droplets within them. (Center) Under certain conditions, a plane may destroy a cloud while flying through it, creating a reverse contrail. (Right) River reflects sunlight.

ered stratus clouds, which have much smaller water droplets and thus scatter less light.

Cloud brightness is also highly dependent on angle from the sun, and as the angle changes, the luminance of the cloud changes. The ordinarily dark stratus clouds are, for instance, brighter than the surrounding sky between the angles of 10 and 45 degrees, then grow gradually darker as the angle changes—until between 80 and 115 degrees they are darker than the surrounding sky.

At about 143 degrees from the sun while flying over a deck of stratus clouds, the striking "fog bow" sometimes is visible. On a graph showing the luminance of clouds at various angles from the sun, the earlier-mentioned peaks occur at zero and 180 degrees. But there is another peak at 143 degrees—which appears to the observer as a bright line of scattered light crossing the cloud deck. Depending on the angle of the aircraft to the sun, the "fog bow" can usually be seen from the shady side of the aircraft "forward of the plane's geometrical shadow position," says Dr. Hall.

Sunsets can be spectacular anywhere, but the airborne observer sometimes sees some things the earthbound viewer misses. If you imagine the straight sun's rays striking the curved earth at the point between daylight and darkness on the earth's surface, then you can also imagine that a wedge-shaped illumination of the sky would occur to the east of that point, defined on the bottom by the earth's shadow. In fact, such a "twilight wedge" can often be seen from aircraft and, depending on atmospheric conditions, it can be highly colorful.

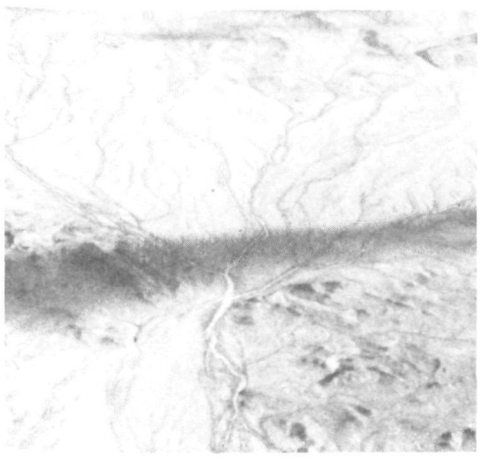
A rainbow results from the wavelength-dependent scattering of light by water droplets, white light being resolved into its component colors, or wavelengths. Closely related to this phenomenon is the "glory," which occurs on the surface of clouds beneath an aircraft when the sun is at an angle between 178 and 180 degrees to the observer's viewing direction. The glory is a series of rainbow-like concentric circles which appear to surround the aircraft's shadow on the layer of clouds beneath the plane. Sometimes as many as five of the varicolored concentric circles can be seen but usually only two or three show brightly enough to photograph.

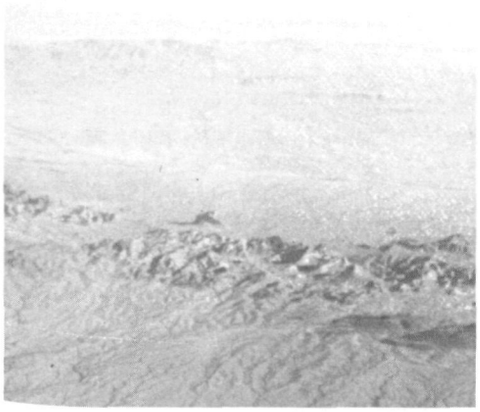
"The heiligenschein, or 'holy light,' is a white halo which appears to surround an observer's head when his shadow is cast on the ground. It is formed by the contrast between the observer's shadow and the unshadowed rough surface such as grass blades, rocks, or trees when the surface is viewed opposite from the sun," says Dr. Hall. "It is greatly accentuated if there is dew on the grass which reflects light back to the observer."

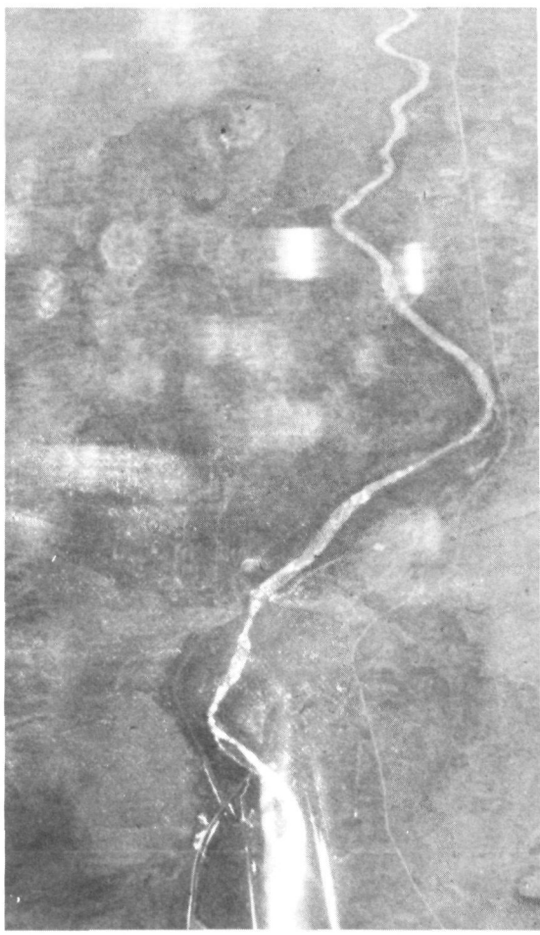
An aircraft, as well as a man standing on the earth, can present a heiligenschein, which can sometimes be seen from the shady side of an aircraft as a bright aura on the ground around the plane's shadow at a low altitude. Even at higher altitudes, when the shadow of the aircraft is no longer visible on the ground, a heiligenschein can be seen at the leading end of the aircraft's contrail shadow.

Contrails — condensation trails — themselves can produce fascinating patterns, especially in heavily traveled air lanes. The contrails are artificial clouds which can be caused by two factors. One is the expansion and cooling of air by lifting surfaces, which causes water vapor to condense. The other is condensation of water vapor from fuel burning in the jet engines. "But," says Dr. Hall, "the result is not always a contrail cloud. Occasionally, when conditions are favorable, planes destroy a cloud when flying through it. What happens is that the aircraft will cause a mixing of dry air above the cloud downward, causing the cloud to evaporate. This can be seen as a dark line through the cloud behind the aircraft."

These are some of the phenomena described by Dr. Hall, but by no means all. The air traveler can be an amateur oceanographer, for instance, judging the depths, and sometimes the currents in oceans, by the spectacular color contrasts—the darker the water, the deeper. And there are numerous kinds of reflections, both from surface features, such as the surfaces of rivers, and from atmospheric components, such as ice crystals, which are oriented in a consistent direction. Even the aircraft windows can demonstrate optical principles, if the observer happens to be wearing polarizing dark glasses. Under strain, the windows exhibit double refraction which is seen through the dark glasses as wavy dark-blue areas in the window. □







Being a bouillabaisse of fascinating facts about

FISH: The most-asked questions

The National Marine Fisheries Service annually answers thousands of questions about the oceans and the life that thrives within them. Questions come from seasoned scientists, from teachers, from elementary school pupils—from a whole host of citizens seeking knowledge that may be highly specialized, or may be rudimentary.

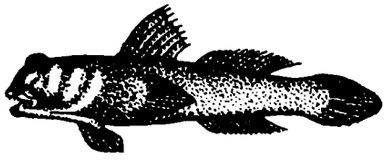
On the basis of a canvass of experienced marine scientists in the Fisheries Service, more than a hundred questions have been chosen as most representative. They are the questions asked most frequently, the topics that people find most interesting. They begin with: **Marine Finfish and How They Live.**

Is life found at all depths in the ocean?
The question was settled in 1960, when Piccard and Walsh reported a swimming animal, resembling a sole or other flatfish about a foot long, at 35,800 feet deep, observed from a porthole of the bathyscaphe *Trieste*.

Some scientists believed, as recently as 1860, that marine life could not exist below 1,800 feet. That view was altered when a telegraph cable laid in the ocean bottom at 6,000 feet deep was retrieved and found covered with many forms of marine life.

How many fish species are there?
The most oft-quoted estimate is 20,000. There may be as many as 20,000 more.

Which is the oldest fish, as a class?
The most primitive fish-like animals are those with sucking mouths, such as lampreys and hagfishes, whose evolution stopped short of the development of biting jaws. Mainly bottom-dwellers, these animals are of great interest to zoologists, for many parts of their bodies show forms and functions that help to explain some of the evolutionary steps leading from low to advanced life forms.



What is the world's largest fish? The smallest?
The largest is the whale shark, which grows to more than 50 feet in length and may weigh several tons; second largest is the basking shark, which may measure 35 to 40 feet long. The smallest fish is the tiny goby, an inhabitant of fresh-to-brackish-water lakes in Luzon, Philippines. It seldom is longer than a half-inch at adulthood, yet is so abundant it supports a fishery.

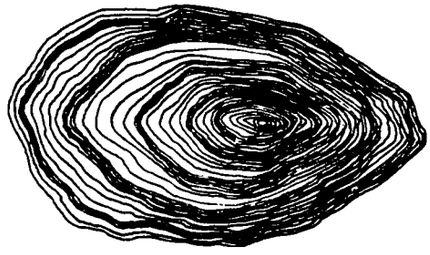
What is the most common fish in the sea?
Any of the several species of *Cyclothone*, a deepwater fish sometimes called a "bristlemouth." Rarely visible at depths that man can readily reach, the fish is about the size of a small minnow. It is netted at 500 meters or deeper all over the world.

What is an anadromous fish? A catadromous fish?
An anadromous fish, born in fresh water, spends most of its life in the sea and returns to fresh water to spawn. Salmon, smelt, shad, striped bass, and sturgeon are common examples. A catadromous fish does the opposite —lives in fresh water and enters salt water to spawn. Most of the eels are catadromous.

Why do scientists classify fish?
Since common or colloquial names of fish vary from place to place (menhaden, for example, are known by at least three different names, and striped bass are called "stripers" in New England and "rockfish" in Chesapeake Bay), investigators would have no way of differentiating among species without a uniform naming system.

The system used to name the 20,000-odd fishes known to science is called "the binomial system of nomenclature." It usually consists of a scientific name in two parts, the generic and specific names, or three parts if subspecies have been described. The words of the names are latinized regardless of the language or alphabet of the study and are frequently descriptive of a significant feature of the organism. The generic name generally applies to several species showing basic characteristics while a specific (species) name is based on a few characteristics applying to one species, separate and distinct from all others. (Example: The generic name *Morone* applies to white perch, white bass, and striped bass; the species names for those three fishes are *Morone americanus, M. chrysops,* and *M. sexatilis*.)

How is the age of a fish determined?
Mainly by two methods: Growth "rings" on scales, and/or ringlike structures found in otoliths (small bones of the inner ear), are examined and counted. The rings correspond to seasonal changes in the environment and can be compared to the annual rings of tree trunks. A series of fine rings are laid down in scales for each year of life—in summer, the rings grow faster and have relatively wide separations; in winter, slower growth is indicated by narrow separations between rings. Each pair of rings indicates one year. Because scale rings are sometimes influenced by other factors, scientists often use otoliths, whose ringlike structures also indicate years of life.



How long do fish live?
A few weeks or months (some of the small reef fishes) to 50 years or more (sturgeons). Longevity information is still sparse, but scientists have learned that species live 10 to 20 years in temperate waters.

Do some fish give birth to living young?
Yes, many do. These are called viviparous fishes. The sea perches of the Pacific coast, for example, give birth to living young of considerable size, sometimes one-fifth the size of the mother. Several kind of sharks produce living young.

Do fish breathe air?
Yes, but not directly into the lungs as mammals do (except for some tropical fish). As

water passes over a system of extremely fine gill membranes, fish absorb the water's oxygen content. Gills contain a network of fine blood vessels (capillaries) that take up the oxygen and diffuse it through the membranes.

How do fish swim? How fast?
Primarily by contracting bands of muscles in sequence on alternate sides of the body so that the tail is whipped very rapidly from side to side in a sculling motion. Vertical fins are used mainly for stabilization. Paired pectoral and pelvic fins are used primarily for stability when a fish hovers, but sometimes may be used to aid rapid forward motion.

Tunas and tuna-like fish, billfish, and certain sharks are the speed champions, reaching 50 miles per hour in short bursts. Sustained swimming speeds generally range from about 5 to 10 miles per hour among strong swimmers.

Can fish swim backwards?
A number can, but usually don't. Those that can are mostly members of one of the eel families.

Do all fish swim in the horizontal position?
Most do. The sea horse is among the exceptions. Another is the shrimp fish of the Indian Ocean, which congregates in schools of several individuals and swims vertically, its long tube-like snout pointing directly upward. A catfish indigenous to the Nile and other African rivers also swims in the vertical posture. Many kinds of midwater deepsea fishes swim or rest vertically.

Do fish chew their food?
Not in the human manner. Carnivorous fish use their sharp teeth to seize and hold prey while swallowing it whole or in large pieces. Bottom dwellers such as rays are equipped with large flat teeth that crush the shellfish they consume. Herbivorous fish (grazers) often lack jaw teeth, but have tooth-like grinding mills in their throats, called pharyngeal teeth. Fish would suffocate if they tried to chew, for chewing would interfere with the passage of water over the gills, necessary for obtaining oxygen.

Can fish distinguish color?
Most fish are colorblind, despite the opinion of many sportfishermen. Fish can see color shadings, reflected light, shape, and movement, which probably accounts for the acceptance or rejection of artificial lures used by fishermen.

Are all fish edible?
Most kinds encountered by anglers are. The organs of some species are always poisonous to man; other fish can become toxic because of elements in their diets. The latter are most often from tropical regions of both the Atlantic and Pacific Oceans. Scientific literature has pinpointed danger areas in which the disease called "ciguatera" (a disease dangerous to man) may occur in tropical and subtropical fish.

How can poisonous fish be distinguished from edible ones?
They cannot, without personal knowledge of the types of fish which are at times poisonous. Frequently local customs can be relied upon. A comprehensive three-volume publication on the subject is entitled "Dangerous Marine Animals" by Dr. Bruce Halstead.

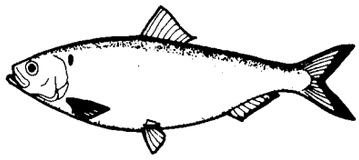
Why do food fish sometimes have a strong odor?
For most species, truly fresh fish is almost odorless. Fish begin to smell "fishy" when deterioration sets in, often caused by incorrect storage practices that bring about the release of oxidized fats and acids through bacterial and enzymatic action.

Is there much salt in fish?
Very little in most. More than 240 species contain so little salt that doctors recommend them in salt-free diets. Shark meat is salty—as salty as the sea the shark lives in.

What is the blood-like material found along the backbone in the body cavity of most fishes?
The kidney. It is usually removed when the fish is cleaned.

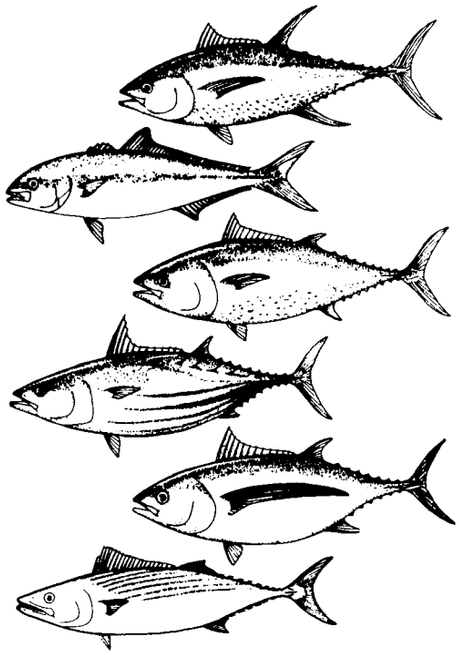
Can shark meat be used as food for humans? Is it true that the meat of the hammerhead shark is poisonous?
Yes to the first question. Shark meat is palatable and nutritious if properly prepared. In some countries shark meat is marketed under its common name, in others it is marketed under various names. The fish in England's "fish and chips" is very often dogfish (a shark) or school shark. The prejudice against shark meat arises from a distaste for the scavenging habits people attribute to sharks, and to the fact that the meat spoils quickly. The meat of certain species is apt to be strongly flavored, a characteristic that may be reduced by icing for 24 hours, then soaking for two hours in brine. Dry salted shark has become a staple food in some countries where salt cod was formerly popular. But shark liver should never be eaten—its high concentrations of vitamins can cause illness in humans.

It is only a rumor that the hammerhead is poisonous.



What is the true description of a sardine?
Commercially, the name has come to signify any small herring-like ocean fish. In the United States, it is mandatory that when the name "sardine" is used on a can, the country or state of origin be listed, and a statement must appear that identifies preserving and flavor supplements.

How many kinds of tuna are there, and which kind makes up the biggest catch?
There are seven commercial and sport-caught tunas, as well as several related species, all of which are members of what is called the scombrid family. Commercially caught tunas consist of albacore, bigeye, blackfin, bluefin, bonito, skipjack, and yellowfin. Yellowfin, taken in the eastern Pacific and tropical Atlantic, makes up the biggest U.S. commercial catch. Albacore, caught in the eastern Pacific, is the true "white-meat" tuna; skipjack, caught throughout the world in tropical and subtropical waters, makes up the second largest U.S. commercial catch; bigeye is caught mostly in tropical waters; blackfin is caught commercially only in the Caribbean and off South America; the very large bluefin (rod-and-reel record, 1,040 pounds) is a highly prized sport catch in the Atlantic and Pacific; and the widely distributed bonito is used largely as pet food.



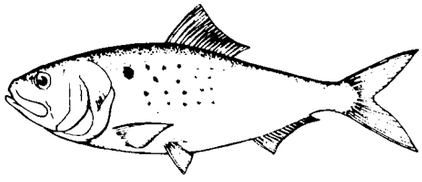
Do tunas have scales?
Yes, all species do, but scales are so small over most of the body as to be nearly invisible. Prominent scaling appears only around the head, on the cheeks, and in a triangular area on each side of the body near the head.

Are saltwater catfish good to eat?
The two species of sea catfish caught in U.S. waters are edible. The gafftopsail catfish is considered more tasty than the smaller common sea catfish.

What is the fish listed as "scrod" in New England restaurants?
The name comes from a Middle Dutch word "schrode" meaning a strip or shred. In New England scrod may be immature cod or haddock weighing 1½ to 2½ pounds. Sometimes the term is applied to cusk of about the same weight, or to pollock weighing 1½ to 4 pounds. When fishermen use the word, they are usually reefrring to gutted small haddock.

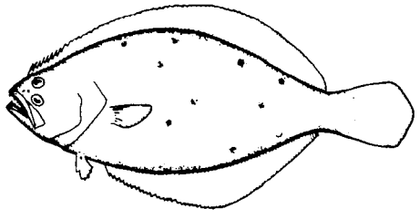
What are menhaden?
Menhaden are silvery, herring-like fish that travel in large schools along the Atlantic and Gulf of Mexico coasts of the United States. Plankton-eaters, menhaden attain a weight of about three-quarters of a pound. Flesh is oily and considered inedible for humans. The

fish are caught by purse-seine nets in shallow water and processed into oil for cosmetics and fish meal for animals, particularly for poultry. Menhaden support the largest fishery by volume and the eighth most profitable fishery in the United States.

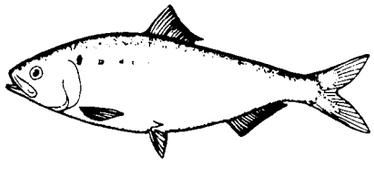


Where are Atlantic menhaden spawned, and where do they go after hatching?
Spawning is in the ocean. One important spawning site is at Onslow Bay, North Carolina. Some spawning takes place along the Atlantic coast from Massachusetts to Florida. The young menhaden first drifts with currents until it reaches an inlet, then works upstream to live for the summer near freshwater. In fall, schools move downstream to permanent ocean residence.

What do herring eat?
They subsist on zooplankton. Herring, which populate the oceans in enormous numbers, play an important role in the oceanic food chain in that they are primary converters of plankton. Herring form the food base for many larger species, and enormous quantities are taken commercially for fish meal, human food, and bait.



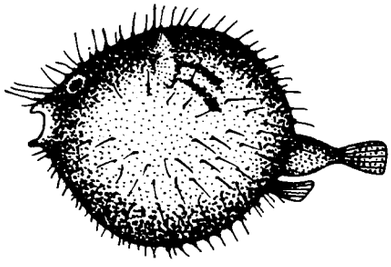
Are the eyes of flatfishes on the right or left side?
Except for the rare abnormal specimen, two of the four flatfish families (tongue soles and turbots) are always sinistral (eyes on the left side); the other two (both flounders) are dextral (eyes on the right side).



Has any kind of marine or ocean dwelling fish been successfully transplanted from coast to coast in the United States?
Yes, larvae and juveniles of the shad and the striped bass were taken from the Atlantic and released in the Pacific in the 1870's. So successful were the transplants that shad became permanent inhabitants of waters from southeast Alaska to Los Angeles, and striped bass support a good sport fishery off the California and Oregon coast.

How large do ocean sunfish get?
All four species reach from seven to ten feet in length. Because of their tremendous weight, the fish are difficult to land and weigh. One accurately weighed specimen tipped the scales at 3,102 pounds.

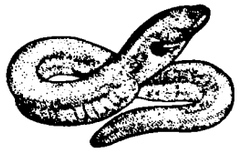
How do porcupine fish inflate themselves?
All puffer-like fish inflate by pumping water into special sacs when in their natural environment. Out of water, a puffer fills the sacs with air instead, and takes on a ballon-like appearance.



What is an "exotic" fish?
One not native to an area, but introduced either by accident or design. Some such species can cause problems. Often their natural predators are absent from the new area, permitting more rapid reproduction rates than those of natural inhabitants, sometimes at the expense of more desirable native fish. The "walking catfish" in Florida is an example. Thought to have escaped from a private aquarium, the catfish have shown a remarkable ability to avoid eradication efforts by man. An aggressive and voracious fish, it poses a threat to other forms of aquatic life. Population is now estimated in the millions.

What fishes are named after other animals?
Many are named after animals—alligator, bird, boar, buffalo, cat, cow, dog, elephant, frog, goat, goose, hawk, horse, leopard, lizard, parrot, porcupine, rabbit, sheep, squirrel, tiger, toad, unicorn, viper, wolf, and zebra.

What kind of fish is a "Bombay Duck"?
Also called bummalo, Bombay Duck is a marine lizardfish from southern Asia, particularly abundant in the Ganges Delta and the Arabian Sea of western India. The ordinarily small fish is split, boned, and sun-dried, and used as a condiment.



How much electricity does an electric eel generate?
The average discharge is more than 350 volts, but discharges as high as 650 volts have been measured. Voltage increase until the eel is about three feet long, after which only amperage increases. Some South American eels measure 10 feet in length.

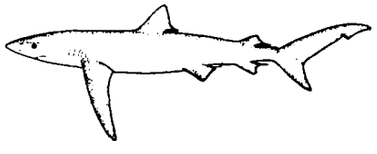
What are moray eels and where are they found?
Moray eels belong to a family of fish which differs from the common eels by their lack of side fins, their well-developed teeth, and their lack of scales. Common eels have embedded scales, but these are not readily noticeable.

Morays occur in tropical and subtropical seas of the world. In the United States, they are usually found in quantity only in Florida waters, although they have been seen as far north as North Carolina and even New Jersey. Little is known of their breeding habits except that the young pass through a stage which is very thin, ribbonlike, and transparent. Morays feed largely on other fish caught as they work their way through coral reefs. Some morays are equipped with teeth in the back of the mouth for crushing hard-shelled animals such as clams and oysters.

Morays are occasionally caught on hook and line by fishermen, sometimes are captured by trawlers that drag nets over the bottom. People in some parts of the world value the moray as food.

Some Pacific morays measure as long as 10 feet and are considered dangerous to man when aggressions are aroused, generally by divers' actions. Several records exist of attacks on humans by wounded morays.

What is pearl essence?
It is the silvery substance in the skin of herring and other fishes. Pearl essence is a lucrative byproduct of herring fisheries inasmuch as it is essential to the manufacture of lipstick, nail polish, paints, ceramics, and costume jewelry.

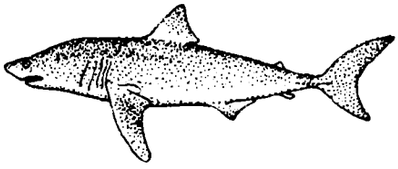


Is the blue shark really blue?
In life the blue shark displays a brilliant blue color on the upper portion of its body and is normally snowy white beneath. The blue quickly fades to dull grey after the shark is killed. The mako and porbeagle sharks also exhibit a blue coloration, but it is not nearly as brilliant as that of a blue shark. In life most sharks are brown, olive, or grayish.

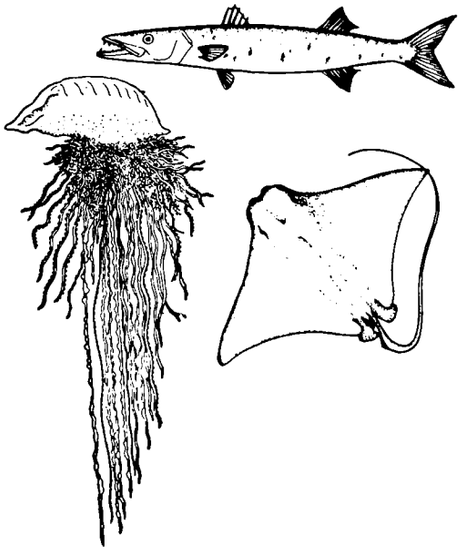
What attracts sharks? Which are most dangerous?
Considerable research has been devoted to finding out what stimuli attract sharks and incite them to attack. Results are mostly inconclusive, but some general principles have been advanced: Certain types of irregular sounds—like those made by a swimmer in trouble or a damaged fish—seem to attract sharks from great distances. Sound, rather than sight or smell, seems to be a shark's primary cue for moving into an area. Some scientific experiments indicate that sharks can distinguish light colors from dark, and that they may even be able to distinguish colors. Yellow, white, and silver seem to

attract sharks. Many divers maintain that clothing, fins, and tanks should be painted in dull colors to avoid shark attacks.

Though blood itself may not attract sharks, its presence in combination with other unusual factors will excite the animals and make them more prone to attack.



The most dangerous species in order of documented attack records are: the great white shark, bull shark, tiger shark, grey nurse shark, lemon shark, blue shark, whaler shark, sand tiger, several species of hammerheads, and the mako. Some species such as the nurse shark are extremely sluggish and have poorly developed teeth, but even these have been known to attack man when excited or disturbed.



What sea creatures other than sharks may be dangerous to swimmers?
The barracuda (though divers claim its ferocious reputation is undeserved), moray eels, octopuses, and sharp-spined sea urchins can be dangerous to swimmers. The Portuguese man-of-war has tentacles up to 50 feet long with specialized cells that produce painful stings and welts on contact by swimmers. Sting rays, toadfish, catfish, and jellyfish can inflict damage on swimmers and waders. Certain coral-reef organisms are to be avoided by divers.

How many species of Pacific salmon are there?
There are six: Chinook, coho, pink, sockeye, chum, and masu. The first five are found in North America. The masu occurs only on the Asiatic coast of the North Pacific.

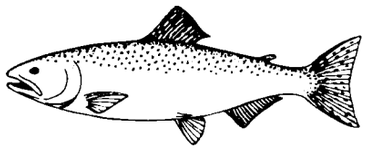
Is it true that salmon return to spawn in freshwater areas where they were born?
Almost always. Some straying has been documented, but it is minor. Most spawning salmon return to the precise stream of their birth, sometimes overcoming great distances and hazardous river conditions to reach home.

What is the difference between the Atlantic salmon and the Pacific salmon?
The Atlantic salmon is actually a member of the genus *Salmo,* or trout family, not a salmon, which is placed in the genus *Oncorhynchus.* The misnomer is so widely accepted that it would only cause confusion to rename the species. The main biological difference between the Atlantic and Pacific "salmons" is that *Salmo* may spawn more than once, and *Oncorhynchus* die soon after one spawn.

Where do salmon go in the ocean?
Contrary to earlier beliefs, many salmon from North American rivers roam far at sea in the North Pacific Ocean and the Bering Sea. The oceanic distribution of the salmon is dependent upon the species and point of origin. Sockeye and chinook salmon from northwest Alaska, for example, may migrate across the Bering Sea to areas close to Kamchatka, U.S.S.R., and south of the Aleutian Islands into the North Pacific Ocean; the sockeye also migrate eastward to the Gulf of Alaska. Salmon such as the pink, chum, and coho from central and southeast Alaska, British Columbia, and Washington State, migrate out into the northeastern Pacific and Gulf of Alaska. Many steelhead trout from Washington and Oregon are known to migrate far at sea to areas off the Alaskan Peninsula. Some salmon migrate several thousand miles from the time they leave the rivers as juveniles until they return as adults. A chinook salmon tagged in the central Aleutian Islands and recovered a year later in the Salmon River, Idaho, had traveled about 3,500 miles; a steelhead trout tagged south of Kiska Island (western Aleutians) was recovered about six months and 2,200 miles later in the Wynoochee River, Washington.

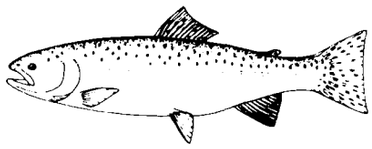
What is a kokanee, or silver trout?
It is the landlocked subspecies of a sockeye salmon. The kokanee spends its entire life in fresh water and usually does not attain the size of its sea-migrating cousin.

Do landlocked Pacific salmon die after spawning?
Yes. This phase of their life history is the same as their seagoing relatives.



How large do salmon get?
Weights of 100 pounds and slightly over have been reported from European countries for the Atlantic salmon; the record for the largest of the Pacific species, chinook, is 261 pounds for a fish caught on commercial gear in Alaskan waters.

What is the oldest known age of salmon and steelhead (in completed years)?
Pacific salmon: chinook—7; sockeye—7; silver—4; chum—6; pink—2
Atlantic salmon: 8
Steelhead trout: 8



Is a steelhead a salmon or a trout?
The steelhead is a rainbow trout that migrates to sea as a juvenile and returns to fresh water as an adult to spawn. Unlike the Pacific salmon, the steelhead trout does not always die following spawning and may spawn more than once and return to the sea after each spawning.

Hold old are salmon when they migrate from fresh water to the ocean?
That depends on species:
Chinook—fall chinook, 3–4 months after hatch; spring chinook, 12–16 months;
Coho—12–24 months;
Chum—a week to a month;
Sockeye—12 months to 36 months;
Pink—a week to a month.

How many eggs do salmon have?
Generally from 2,500 to 7,000 depending on species and size of fish. The chinook salmon generally produces the most and largest eggs.

What are salmon fed in a hatchery?
Vitamin-rich, high-protein diets made up of dried meals from coarse fish, animal meat excess, plant meal and bone meal, or meal from calcium-rich shells.

How many of the young salmon released from hatcheries come back as adults?
Releases of large fingerlings usually result in returns of one to five percent.

Why are fishladders constructed?
A fishladder, or fishway, often used in salmon country, is constructed to provide for upstream passage of fish over a dam or a natural barrier that might prevent or impede progress to spawning grounds.

How can I maintain a small saltwater aquarium?
Three principal rules must be followed:
(1) Keep it clean. Remove excess food, coral, algae, and miscellaneous debris. Omit over-decoration with coral, sponges, and other marine plants. Marine aquariums are vulnerable to pollution by spoiled food.
(2) Stock sparingly, using no more than a single one-inch-long fish per gallon of water capacity.
(3) Use quartz sand on a sub-sand filter in the bottom of the aquarium. Good filtration is vital. In addition, some monitoring of fish behavior is advisable—fin-nipping, for instance, may be a sign of problems. Consult literature for precise information.

(To be continued)

Weather instruments old and new sit side by side at Haswell, Colorado, where ERL scientists are calibrating

SENSORS FOR THE TWENTY-FIRST CENTURY

BY JAMES C. RUDOSKY

Lasers string crimson light beams through the air over the southern Colorado prairie, linking photo sensors in a net of light.

Acoustic antennas cupped skyward emit birdlike chirps, then listen for echoes from the layers of air stacked like pancakes above the shallow bowl-shaped depression.

An ear-shaped radio antenna listens to the microwave signals from atmospheric oxygen.

Radar beams probe the sky searching the atmosphere for regions of turbulence or convective activity.

Ultra-sensitive microbarometers monitor the atmosphere for invisible pressure waves passing overhead.

And, a giant among the smaller instruments scattered across the ground, the webbed steel of a meteorological tower holds instruments aloft, measuring the temperature and pulse of the atmosphere.

A glimpse of the future? That, and a look at the reecnt past. It is an array of traditional and futuristic instruments of Haswell, Colorado, about 130 miles southeast of Denver during a recent unique comparison of what is old and new in atmospheric sensors by scientists of NOAA's Environmental Research Laboratories.

"When these remote-sensing systems are perfected," says Dr. C. Gordon Little, Director of the Wave Propagation Laboratory, "they will play a major role in weather prediction and control. Some may well be standard equipment for weather stations by the year 2000—in certain cases much earlier.

"Preliminary results indicate that our ground-based remote-sensing systems accurately monitor atmospheric conditions which could previously only be measured aloft by instrumented balloons (radiosondes), rockets, and airplanes. Not only are these older techniques inflexible, but they can provide only intermittent glimpses along very limited trajectories through the atmosphere.

"Satellites have recently given us a global atmospheric picture but they cannot provide detailed information on small-scale meteorological conditions comparable to our new ground-based remote-sensing capabilities."

By using the remote-sensing systems they are evaluating and a multitude of more conventional meteorological instruments, NOAA scientists were also able to take a unique look at the atmospheric boundary layer.

"Although all human activities are affected by it, much is still unknown about the dynamics of the atmospheric boundary layer," says Dr. Earl Gossard, project director. "The lower atmosphere is often filled with internal waves set in motion by air flow over mountain ranges, thunderstorms, or weather fronts. It often contains atmospheric temperature inversions, masses of warm air lying above layers of cold air, that serve to trap pollutants and lead to pollution conditions. Or it contains thermal plumes, blobs of sun-heated air that bubble through the surrounding air until they cool or are trapped by an upper layer of warm air.

"Last summer we were able to make unique studies of these and other naturally occurring atmospheric phenomena."

The site near Haswell was chosen to take advantage of an existing 500-foot meteorological tower with meteorological instruments located every 100 feet and on a mobile platform. The instruments included microwave spectrometers and thermistors for humidity and temperature measurements, high-speed thermometers and hot-wire anemometers to measure temperature and wind speed differences between two points 20 centimeters apart, and bivanes for three-dimensional wind measurements.

The site's predictable atmospheric conditions also made it desirable. On clear nights, a blanket of cold air fills the 14-mile-wide, 200-foot-deep natural bowl of the site. The result is an extremely stable air mass with the cold heavy air below warmer, lighter air aloft.

During the day, conditions change radically. The lowest layers of air are warmed by contact with the sunbaked ground, and become hotter than the air above. This condition is unstable, and thermal plumes form intermittently and force their way through the cooler air aloft.

The focal point of the project was a column of air approximately 180 meters (one yard equals .9 meter) square and 150 meters high immediately next to the tower where scientists could compare measurements made by conventional instruments on the tower and remote-sensing instruments stationed on the ground, including

a microwave radiometer, microbarographs, three helium-neon lasers, and three acoustic sounders, both forming triangles 270 meters on a side.

Five miles west and north of the tower, two doppler radar units monitored wind direction and speed over a 16-square-kilometer area around and including the site. As chaff was released into the air and carried through the tower area, it was tracked by the radar units, permitting project scientists to compare wind measurements recorded by tower anemometers and by the radars.

To facilitate intercomparison, data from all instruments were digitally recorded on magnetic tape and synchronized with time broadcasts from the National Bureau of Standards' radio station WWV.

Aiding the collection of data from conventional meteorological instruments were the Environmental Research Laboratories' Air Resources Laboratories, the National Center for Atmospheric Research, and the 6th Weather Squadron, U.S. Air Force.

Presently pilots only know the wind direction and velocity along the runway as measured at a single location by an anemometer, and they therefore cannot accurately correct for winds along the entire runway length.

Remote sensing has a probable solution to this problem. Robert Lawrence, chief of the Wave Propagation Laboratory's optical propagation program, and his group, have applied lasers to monitoring the velocity and movement of large masses of air.

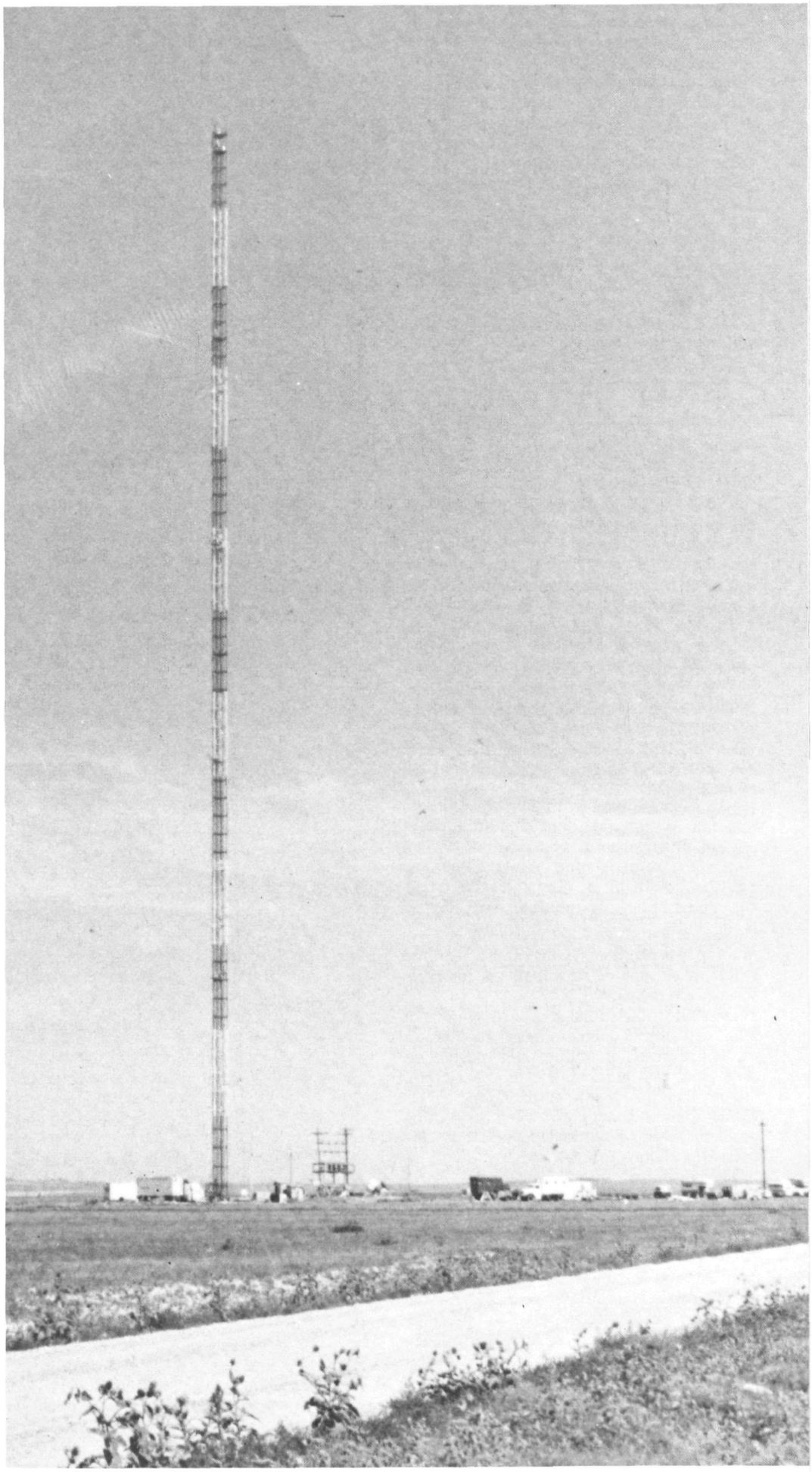
A laser beam directed parallel to the runway could provide the direction and velocity averaged along the total length of the runway and could therefore enable the pilots to plan more accurately their approaches and departures.

This is possible because of two natural phenomena: the continual presence in the atmosphere of slight temperature and, therefore, density fluctuations over small distances, and the fact that light is diffracted or bent as it encounters even the faintest changes in air density.

When air density irregularities cross a laser beam, the light rays are diffracted. In order to calculate wind velocity, Lawrence and co-workers measure the time required for the diffraction pattern to move between two light sensors arranged side-by-side within the beam.

Aside from aiding pilots, a laser beam traversing a city could be applied to the forecasting of air pollution.

Air pollution monitoring requires observation of movements of volumes of air.



At the Haswell, Colorado, site, a 500-foot meteorological tower is instrumented with microwave refractometers for humidity measurements, high-speed thermometers and hot-wire anemometers to measure temperature and wind velocity, and bivanes for three-dimensional wind measurements.

With conventional instruments this is possible only with a number of anemometers located on towers throughout the area. Information gathered from this type of system only tells scientists the wind velocity and direction at selected sites and not the average air flow over the entire area. Lasers would be able to monitor the direction and velocity of a total volume of air.

The Wave Propagation Laboratory is also developing a modified type of laser to measure temperature, humidity, and altitudes of clouds, to identify gases, and to monitor suspended particles. This instrument, called lidar (a combination of the words "light" and "radar"), emits light in pulses and senses the backscattered radiation from within the atmosphere.

Three natural phenomena give lidar its unique measuring and identifying capabilities.

The first natural phenomenon, called the Raman effect, is that some of the light energy scattered by air molecules undergoes a change in wave length by an amount specific to each type of molecule. This may be used to identify the constituents of the air, an important factor in the analysis of air pollution.

The second phenomenon is that as air is heated it expands and becomes less dense. Thus, less light scatters back to the lidar receiver when the air is warm and the molecules are farther apart.

The third phenomenon is that the concentration of nitrogen in the atmosphere is virtually constant worldwide. Consequently, when less light is scattered back from nitrogen molecules, it is due exclusively to the temperature of the air. Wave Propagation Laboratory scientists can determine the altitude of the reflected light by timing the return of the backscattered light pulse. Lidar observations are presently limited to approximately one kilometer in altitude, but Dr. Vernon E. Derr, chief of the laboratory's atmospheric spectroscopy program, believes more powerful lasers will enable them to reach an altitude of 80 kilometers for aerosol measurements.

Derr also feels that the capabilities of lidar will enable meteorologists to monitor the temperature, humidity, and movements of gaseous and particulate atmospheric pollutants identified by lidar techniques. This would allow them to know when a pollution problem is going to develop and take the necessary actions to prevent it.

The inversion interface between warm and cold atmospheric layers undulates in enormous internal waves as much as 200 meters in height from trough to crest. Although in its ascent a radiosonde could pass through a trough or a crest, leading to a grossly inaccurate estimate of the inversion height and pollution potenial, atmospheric inversions have hitherto been monitored almost exclusively by radiosondes.

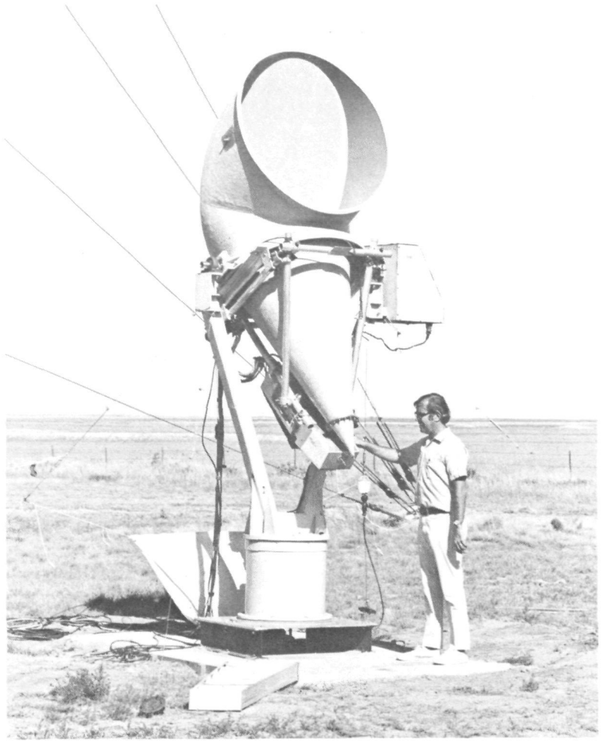
Under the direction of Dr. Freeman Hall, chief of the Wave Propagation Laboratory's acoustic program, this problem may be eliminated by continuously monitoring the moving inversion interface using acoustic echo sounders. This technique is based on the fact that sound traveling through the atmosphere echoes with greater intensity when it encounters a region of increased temperature fluctuations.

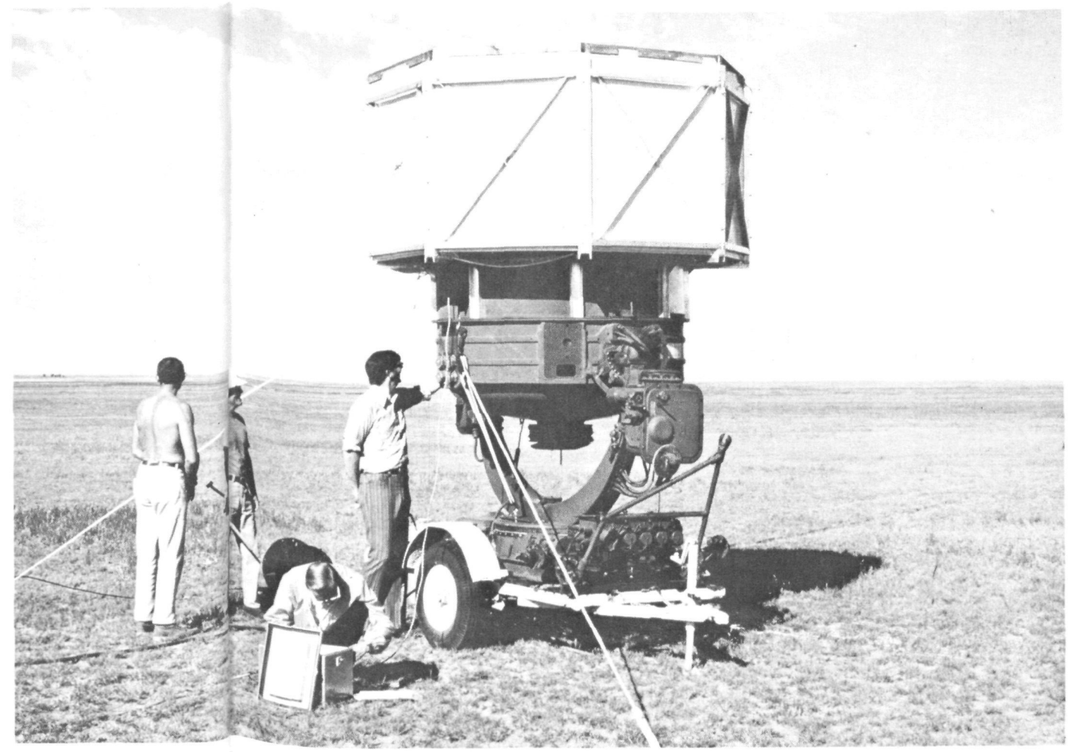
Shaped like a large octagonal box, the acoustic sounder consists of a loudspeaker/microphone that sends sound pulses into the atmosphere. As the 2000-cycle-per-second tone travels through the air, it encounters air layers of different temperature and, therefore, different density.

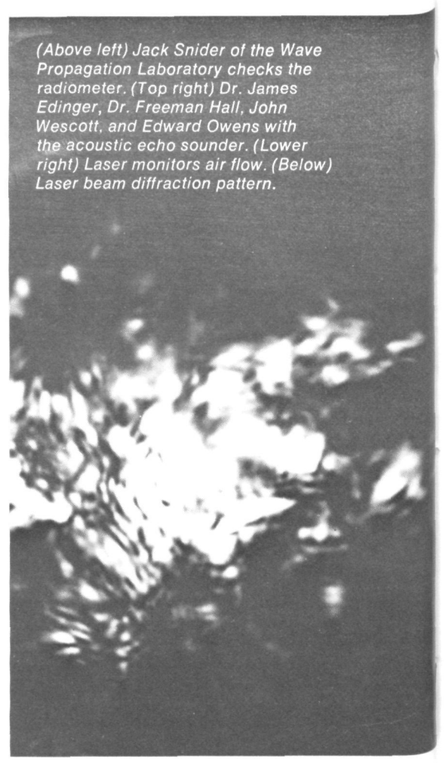
From the intensity of the echo, scientists can determine the relative intensity of temperature fluctuations (although not the temperature in degrees) of atmospheric layers. And by noting the time between transmission and echo return, they can measure, within one meter, the heights of layers up to 360 meters in altitude. The instrument provides them with a graphic illustration of inversion undulations, enabling them to predict the dispersion of pollutants through rising thermal plumes—blobs of sun-heated air that break through surrounding regions of cooler air.

Radiating in all directions with wave periods of six to twelve minutes and amplitudes of up to 200 meters, internal waves can be monitored by acoustic sounders and pressure sensors called microbarometers.

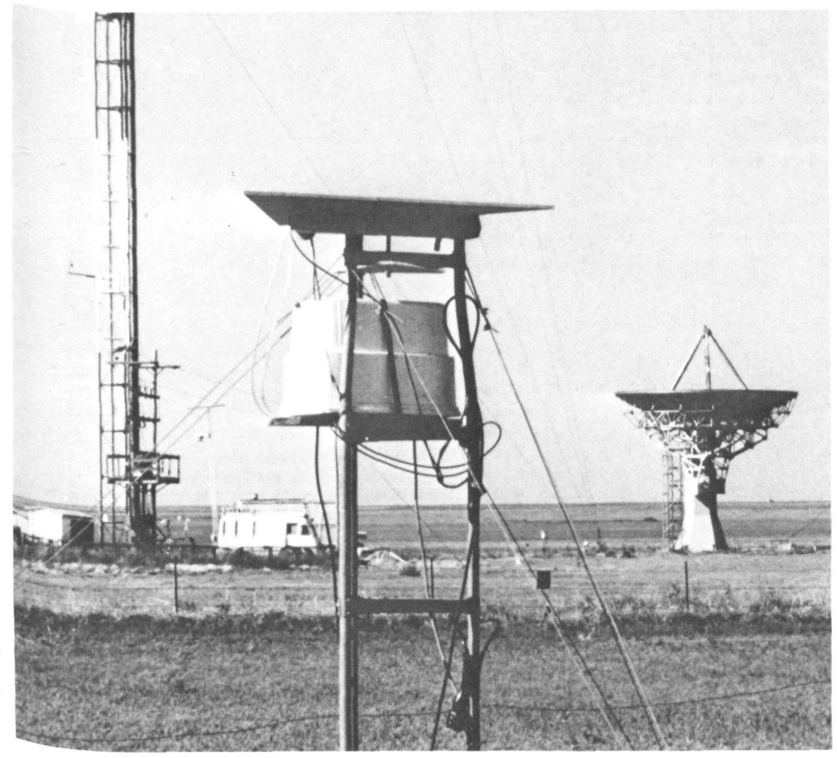
Passing over a ground-based microbarometer, wave troughs and crests cause fluctuations in the surface atmospheric pressure.







(Above left) Jack Snider of the Wave Propagation Laboratory checks the radiometer. (Top right) Dr. James Edinger, Dr. Freeman Hall, John Wescott, and Edward Owens with the acoustic echo sounder. (Lower right) Laser monitors air flow. (Below) Laser beam diffraction pattern.



Unlike the acoustic sounder which probes the atmosphere with pulses of sound and then records the altitude of density layer interfaces, the microbarometer passively measures pressure fluctuations at the ground, caused by density layer undulations at indeterminate altitudes.

At last summer's Haswell experiment, three acoustic sounders and three microbarometers were approximately co-located. The three sounders afforded the Hall group the ability to determine both the horizontal and vertical velocity drift of the plumes and internal waves. Simultaneously, microbarometers provided pressure perturbation data at the earth's surface.

While acoustic sounding measures the relative temperature of atmospheric layers, another ground-based remote-sensing instrument—the radiometer—makes absolute temperature measurements of the atmosphere. Shaped like a large "horn of plenty," the radiometer measures the radiation emitted by oxygen molecules, the intensity of which is controlled by temperature. With this information Martin T. Decker, chief of the Wave Propagation Laboratory's radiometry program, and other radiometry scientists and mathematicians calculate the temperature structure of the atmosphere at altitudes up to five kilometers.

Radiometric measurements may soon be used in urban pollution forecasts. Data collected from radiometers placed around metropolitan areas would allow environmental scientists to monitor temperature inversions as an aid in predicting the formation and breakup of pollution episodes.

Using still another remote-sensing technique, Richard Strauch, acting chief of the Wave Propagation Laboratory's meteorological doppler radar program and his coworkers, explored thunderstorms and clear-air convection with a dual-doppler-radar system. In addition to determining the amount and distribution of rainfall, as is done with conventional radar, the doppler system can measure the velocity at which suspended particles (water and ice in this case) travel away from or towards its antenna. With two radars, Strauch and his group are able to determine the true wind direction and velocity within storm systems, permitting them to study the formation and dynamics of storms and to detect severe storms with potentially damaging winds.

Chaff (metallized nylon fibers) shot into the atmosphere with rockets or dropped from airplanes also allowed the doppler scientists to track the direction and velocity of non-storm winds. With this technique, the air flow of remote areas can be monitored from a distance of as much as 60 kilometers.

When these remote-sensing systems have been thoroughly tested and calibrated, they will be capable of continuously monitoring atmospheric conditions from the ground with almost no human supervision. As such they will be a giant step forward in man's quest to be able to observe, understand, and predict the weather. □

To protect our living marine resources, 25 NMFS enforcement agents keep watch on fishing operations in United States waters.

THE NATION'S FISH PATROL

BY JOHN A. GUINAN

(Left) A Soviet trawler with a small catch of mackerel and herring. (Above) Raymond Fritz, Chief of Enforcement and Surveillance for NMFS, with agents Milstead Zahn and William Allen, documents materials aboard a ship seized for fisheries violations.

"When I go to work in the morning, I'm never sure when I'll get home again—or what might happen. But if I didn't like the work, I wouldn't be doing it."

Those are the words of a National Marine Fisheries Service enforcement agent, describing his job of protecting the nation's renewable marine resources by keeping watch on the operations of domestic and foreign fishing vessels in United States waters.

Working aboard planes and ships of the U.S. Coast Guard and on other carriers, NMFS enforcement agents provide the fisheries expertise needed to distinguish between legal and illegal marine fishing. The enforcement division consists of 25 men who annually fly about 300,000 miles on surveillance flights, log another 120,000 nautical miles on surface patrols, and conduct more than 5,000 dockside inspections as U.S. vessels unload fish catches. Their function is to enforce U.S. regulations implementing some of the 18 international fisheries agreements in existence. Theirs is a job whose scope expands and becomes more complex as additional ships join the large international fleet fishing off the coasts of the United States.

Since World War II, foreign fishing has increased markedly. Sightings of foreign vessels off our coasts vary from month to month, but currently fall within a range of 250 to 1,500 per month.

The contribution made by NMFS enforcement agents can be illustrated by two incidents involving foreign fisheries which received widespread publicity in 1972. One involved a quarter-million-dollar fine levied against two Soviet vessels and their officers for illegal fisheries operations in the Bering Sea.

The second incident involved two Japanese fishing vessels that were apprehended in April 1972 for illegal activities less than 10 miles off Sitkalidak Island near Kodiak, Alaska. The two shipmasters pleaded *nolo contendere* (no contest) to the criminal charges and were fined $15,000 each; in lieu of a civil action against the two vessels, a settlement of $150,000 was reached. Legal action by the U.S. government was concluded after the Japanese had paid the $180,000 total.

NOAA and its National Marine Fisheries Service are concerned with enforcing laws and international agreements covering fishing in certain areas of our coastal waters and the high seas. The United States claims a three-mile territorial sea and an additional nine miles as a fisheries jurisdiction zone, which creates an area 12 miles wide in which fishing in contiguous waters is under the exclusive jurisdiction of the United States.

The United States participates in a number of international fisheries conservation commissions, and is a party to several bilateral fisheries agreements. Recommendations of the international commissions are usually formalized as regulations by the member nations and may deal with catch quotas, size limits, closed seasons, restricted fishing areas, and gear restrictions.

Except when permitted by treaty, foreign vessels fishing inside the 12-mile fisheries jurisdiction of the United States may be seized for Federal court action. Violations of fishing agreements on the high seas are treated under the international law created by the agreement in question which generally stipulates that foreign vessels cannot be seized on the high seas, but can only be reported through the Department of State to their own government for action by the home government. Under a few treaties, however, the United States is permitted to seize and hold violators while the appropriate foreign government is notified. After notification, the offending vessel and crew usually are returned to the other country, sometimes with the vessel's hold and/or gear sealed to discourage tampering with the evidence.

Another excellent example of how enforcement agents may implement an international convention occurred in July 1972, when four Japanese salmon gillnetters, each privately owned, were sighted by a joint Coast Guard-NMFS fisheries patrol flight about 60 miles south of the Trinity Islands, near Kodiak, Alaska. When sighted, the vessels were some 700 miles east of a line delineated in the International North Pacific Fisheries Convention, signed by Canada, Japan, and the United States. Japan had agreed not to fish for salmon east of this line. Salmon were seen on the deck of each ship, and—in a hasty departure from the illegal region—each vessel abandoned several miles of netting.

The ships fanned out, but were kept under constant aerial surveillance by relays of Coast Guard aircraft carrying NMFS fisheries enforcement agents during the night of July 12 and part of the next day. As the chase moved in a generally southerly direction, heading toward Japan, one of the Coast Guard 130's dropped a radio marker beacon to facilitate later location of the nets. Observers could see fish in the nets from the aircraft.

During the daylight hours of July 13, three Coast Guard cutters converged on the fleeing vessels and took them into custody. One of the first cutters to arrive on the scene had been diverted from a Seattle-Arctic assignment. NMFS enforcement agents who accompanied the Coast Guard boarding parties verified that there were salmon in various quantities aboard each vessel. A fourth Coast Guard cutter went to the abandoned nets and remained on station until the Japanese vessels were brought back to retrieve their nets the following day.

Two of the cutters escorted the four Japanese ships into Kodiak, where a dockside inspection confirmed that salmon catches remained in the holds. The main hold of one vessel contained about 14,000 salmon, and lesser numbers of salmon were located in other holds—a clear violation of international agreements.

In Kodiak, each Japanese captain was interrogated by fishery enforcement agents assisted by an interpreter from the U.S. Customs Office. The vessels, their captains, and the ship's documents were held in custody until the arrival of a Japanese government enforcement vessel which had been patrolling along the abstention line violated by the four vessels.

United States officials met with Japanese enforcement personnel and described the violation, citing the available evidence and the ships' documents. The latter were returned to the vessels when they left, under escort of the Japanese enforcement vessel, to await disciplinary action by the Japanese government for violation of an international convention. Later it was learned that as punishment by their government, all four vessels had their licenses revoked, prohibiting them from fishing for salmon during the 1973 season, and the captains and crews are facing criminal charges.

NOAA and NMFS officials commented after the event that the efficiency of the 36-hour chase and the cooperation of the Japanese government demonstrated the effectiveness of international fisheries agreements, properly implemented. Each such incident helps significantly to carry out the underlying principle involved in the agreements—to conserve living renewable marine resources in such a way as to permit maximum catches while attempting to assure that the resource will remain available for future generations.

Two of the busiest areas for enforcement agents are off the coasts of New England and the Northwest Pacific. In New England, agents operate from stations at Gloucester and Provincetown, Mass.; in the Northwest the force is concentrated at Seattle, Washington, and Juneau and Kodiak, Alaska. Other agents reconnoiter waters of the Gulf, Caribbean, and South Atlantic from a St. Petersburg, Fla., location.

Inside the U.S. three-mile limit, domestic fishing vessels are subject to state regulation and enforcement except where Federal law or international treaties take precedence, for example the treaties covering northern fur seals, whales, Fraser River pink and sockeye salmon, and North Pacific halibut. In international conservation areas, either inside or outside the three-mile territorial sea where fisheries are regulated under international treaties, enforcement is a responsibility of NMFS agents. Many states also set controls on fishing outside their territorial waters by regulating the landing or transportation of fish taken outside state waters.

NMFS turns over its fisheries violation cases to the U.S. Attorney for prosecution. Penalties may be in the form of fines, confiscation of catch or gear, imprisonment, or a combination of these.

The fisheries of New England have a particularly high stake in international cooperation for management of fish stocks, because so many fishermen from other nations fish the Northwest Atlantic. Before 1969, protective measures for the area

from Rhode Island north and east to Davis Strait were limited almost exclusively to international mesh size regulations, implemented through the International Commission for the Northwest Atlantic Fisheries. At that time, a severe decline in the haddock resource—blamed on poor survival of young haddock over a five-year study period combined with heavy fishing pressure—dramatically pointed up the need for a better conservation program.

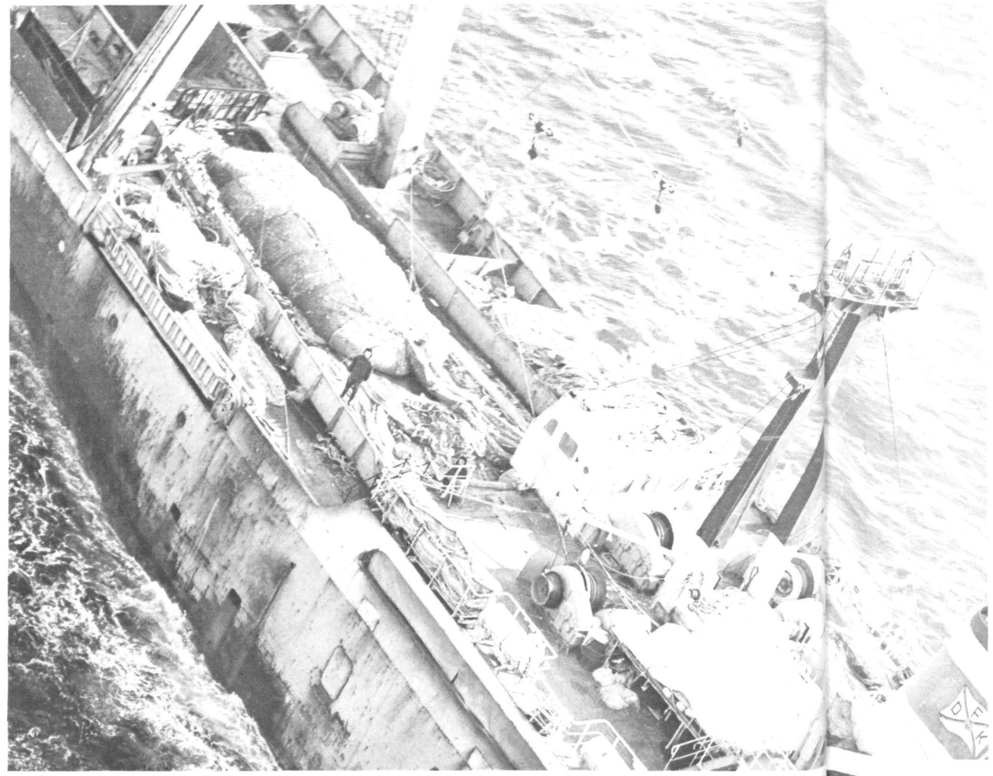
Regulations effective January 1, 1970, issued pursuant to commission proposals, set limitations on quantities of haddock taken on Georges Bank and Brown's Bank off the Atlantic Coast, and placed area restrictions to protect spawning concentrations of haddock. Fishing pressure was also limited on red and silver hake. Since then new proposals of the 16-member commission have led to implementation of national catch quota regulations for Atlantic herring as well as for yellowtail flounder, silver hake, red hake, and cod.

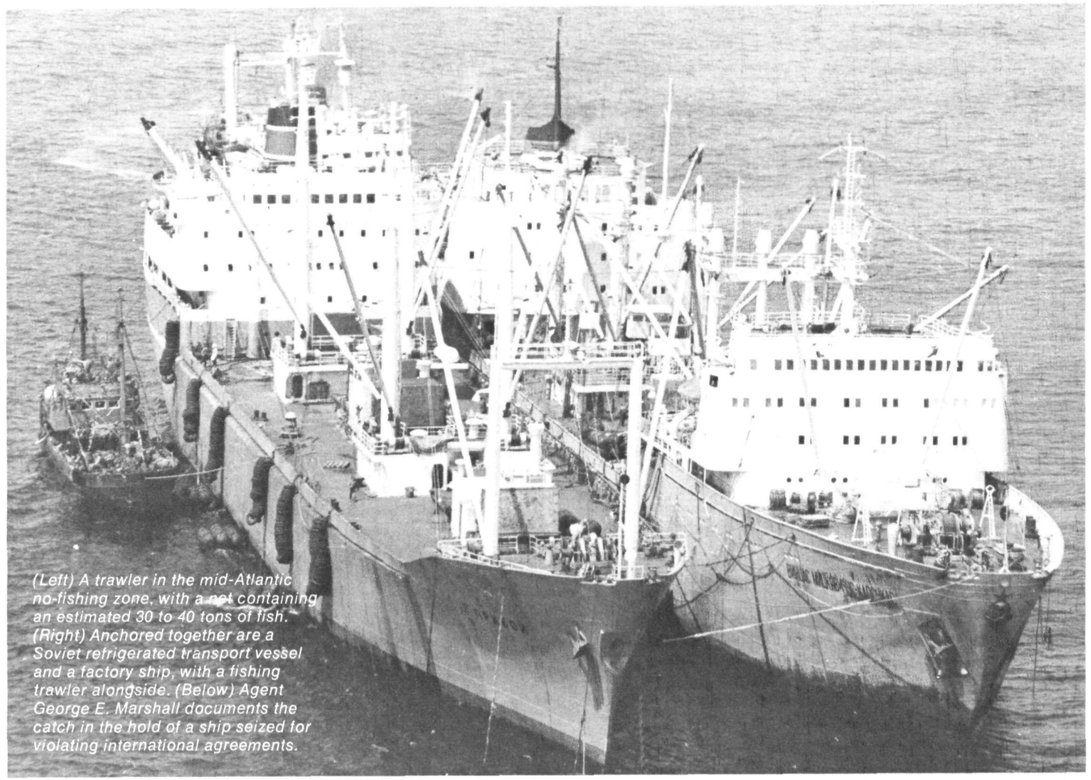
The United States also has negotiated bilateral agreements with the Soviet Union and Poland to protect Middle Atlantic (Long Island to North Carolina) stocks of traditional importance to American fishermen. The agreements with the Soviet Union and Poland restrict their catches of hake, scup, flounder, menhaden, river herring, and black sea bass.

To protect Alaskan fishermen, ongoing agreements renegotiated in late 1970 and early 1971 with Japan and the U.S.S.R. reduced by more than 50 percent the king crab quotas of both nations, placed additional restrictions on their catches of Tanner crabs, and provided curbs on foreign fishing for the benefit of the U.S. halibut fishery. Other portions of the agreements forbade the use, in certain areas and seasons, of gear that would damage crab pots used by domestic fishermen. The agreements with Japan were renegotiated in late 1972 resulting in further restrictions on Japanese fisheries for king and Tanner crab and other species of interest to the United States.

In the North Pacific, some stocks of halibut, herring, and salmon are protected under terms of an agreement first negotiated in 1951 among the United States, Japan, and Canada. The agreement contains the "abstention principle," under which each of the concerned nations agrees not to enter a fishery on fully utilized stocks regulated scientifically to maintain the "maximum sustainable yield."

It takes a special sort of person to be a fisheries enforcement agent. The duties involve irregular, unscheduled hours, personal risks, exposure to all kinds of weather, considerable and prolonged travel, risky sea boardings, and low-level, turbulent aircraft flights. Agents are given broad enforcement authority in carrying out their duties. Because many of their contacts are with foreign nationals, an agent who is untrained or unequipped to carry out his duties could bring discredit or embarrassment to the United States. But the job is rarely a dull one.



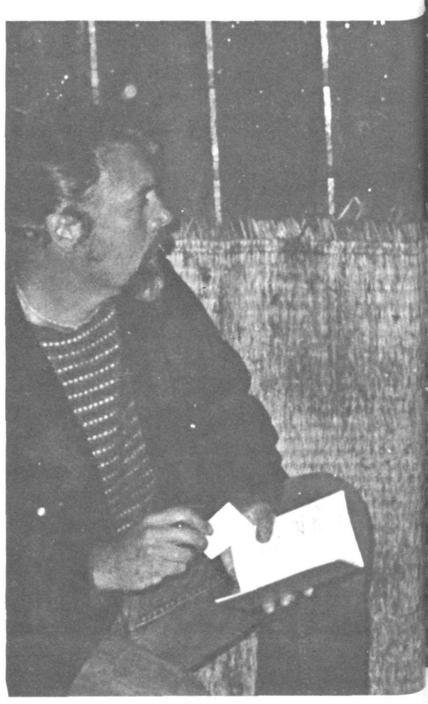


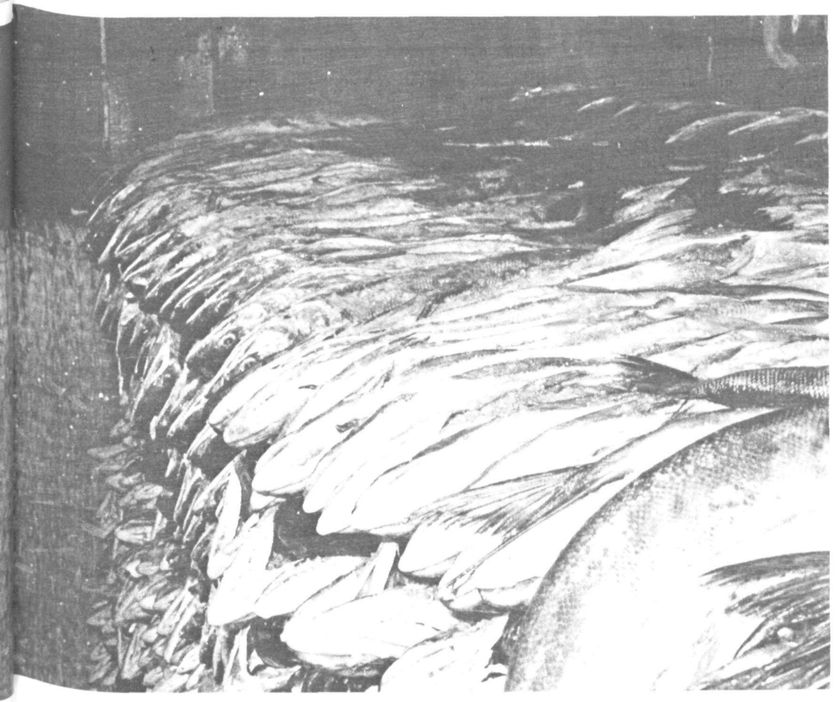
(Left) A trawler in the mid-Atlantic no-fishing zone, with a net containing an estimated 30 to 40 tons of fish. (Right) Anchored together are a Soviet refrigerated transport vessel and a factory ship, with a fishing trawler alongside. (Below) Agent George E. Marshall documents the catch in the hold of a ship seized for violating international agreements.

Many of the NMFS agents moved into their enforcement jobs from other fisheries specialist positions. Others come from a variety of educational and occupational backgrounds. Agent Wayne Lewis, now an administrator in the Washington office of the Enforcement and Surveillance Division, is a lawyer who interned as a prosecuting attorney in Oregon after spending 11 years as a fish and game enforcement officer with the Oregon State Police. He joined NMFS in Alaska in 1971.

Ronald C. Naab of Juneau, Alaska, holds a bachelor of science degree in fish and game management; John C. Hammond of the same region holds a degree in business administration and formerly worked with the Coast Guard's Intelligence and Law Enforcement Bureau. Two other fisheries agents in Alaska, Milstead C. Zahn and Jim H. Branson, are licensed pilots.

Allan F. Mager of Provincetown, Mass., is a former school teacher with a bachelor's degree in education. Daniel Russ of Gloucester, Mass., transferred from the Interior Department's Bureau of Sport Fisheries and Wildlife, where he had been a game management agent; Ernest J. Medico, also of Gloucester, commanded a Coast Guard vessel during World War II and for 12 years worked for the fisheries service in exploratory fishing and gear research. Charles M. Fuss of St. Petersburg, Fla., has a master's degree in biology.





The United States gains much more than the mere arrest of violators by maintaining a staff of fisheries enforcement agents. Surveillance helps assure that our territorial waters and the contiguous fisheries zone are respected and that the provisions of international agreements are observed by foreign fleets. Additionally, information derived from U.S. surveillance work is used in formulating international fisheries policy. Not only does this information allow the United States to follow the innovations and trends in foreign fishing vessels and gear, but it provides estimates of foreign catches, fleet movements, and other information vital to negotiations for new agreements or amendments to existing agreements.

Average citizens, especially those who live outside coastal areas, probably give little thought to international fisheries agreements, but they are important to many thousands of people in this country and throughout the world who earn their living in the fisheries. The work of the U.S. fisheries enforcement agent is seldom mentioned by news media except in time of crisis, but day in and day out he's on the job protecting the interests of the United States and its citizens. □

NOAA Profile

From reports of rattling windows and broken china, an ERL employee rates the intensity of earthquakes.

Mrs. Scott and the Mercalli Scale

BY JOAN VANDIVER FRISCH

"Pool water splashed as if someone took a dive . . . A house disappeared, others collapsed around it. . . . A stopped clock began ticking again. . . ."

As matter-of-factly as an Agatha Christie plotting the fictional progress of crimes both ordinary and bizarre, a silver-haired, soft-spoken grandmother in San Francisco describes our earthquakes—minor tremors and seismic catastrophes alike—in the curious blend of broken bricabrac and ruined cities that is the work of earthquakes. To seismologists around the world, the Environmental Research Laboratories' Nina Greene Scott has been the calm, quiet voice of earthquakes felt in the United States for the past 30 years.

"My work involves the Earthquake Questionnaire Survey Program," Mrs. Scott explains. "Whenever an earthquake is felt in any part of the United States, ERL's National Earthquake Information Center in Boulder, Colo., sends out postcard questionnaires to postmasters at the earthquake location to obtain as much information as possible."

If the earthquake is small in terms of magnitude, intensity, or significance, the earthquake center relies only on the information returned from the questionnaires, National Weather Service reports, a newspaper clipping service, and mechanical records of the event to evaluate the earthquake.

In the case of very destructive earthquakes, such as the San Fernando, California, earthquake of February 1971, the Earth Sciences Laboratories also send geophysicists to the site to conduct field invesigations and gather additional verbal information. When the data is collected, the earthquake center sends the information to Mrs. Scott to evaluate at the Seismological Field Survey, part of ERL's Earth Sciences Laboratories, in San Francisco.

"I rate all earthquakes according to their intensity, which is an indication of an earthquake's severity at a specified location as described by experienced observers," she says. "I then translate their descriptions into values on the Modified Mercalli Intensity Scale, generally used in the United States, which grades observed effects into 12 classes ranging from I, felt only under favorable circumstances, to XII, damage total." By matching information contained in the postcards and other sources with the definitions, Mrs. Scott evaluates the earthquakes.

"Intensity is not the same as magnitude," she points out, "which expresses the 'absolute' size of an earthquake as determined from measured seismic wave amplitudes and rated on a scale developed by Dr. Charles Richter. Magnitude also provides an indication of earthquake energy release, which intensity does not."

Lots of people rely upon Mrs. Scott. James F. Lander, chief of the earthquake center in Boulder, for example, says, "She has personally evaluated the intensities for almost all United States earthquakes for many years. For this reason, Mrs. Scott has developed a valuable and objective set of data from very subjective information. If more than one person had been evaluating the intensities, our data would not be nearly as accurate."

After she evaluates an earthquake, the results are transferred to key punch cards and fed to a CDC 6400 computer which plots the intensity map of the earthquake. The result — an isoseismal map — describes numerically areas of equal intensity radiating from the earthquake's epicenter. The maps are printed by the earthquake center in Boulder. Much of the same information is used in *Abstracts of Earthquake Reports for the United States*, the principal publication that she compiles, which is published quarterly by NOAA's Environmental Data Service, and *United States Earthquakes*, another EDS publication.

The information Mrs. Scott compiles is sent to all interested government and university seismologists, engineers, and insurance companies. If a university needs the information before it is published in abstract form, the earthquake center will send them her raw data. Some universities still conduct their own supplemental surveys because they can interview private citizens, but most rely on her compilations from the information center questionnaire program as an adequate source of information.

Mrs. Scott began her government career in 1939 as a clerk-stenographer in San Francisco's Appraiser's Building. When the city demolished the building in 1940, her office was moved to the United States Mint.

"I began recording earthquakes on my own while in that building," she says. "My office was in the basement of the 'old relic' when the damaging earthquake of March 22, 1957, struck. I was leaning over a bit at the time and said to myself, 'That was a strong one,' but no one else in the office seemed to be excited. I was stunned but not really frightened."

As she later learned, that earthquake was the strongest felt in San Francisco since 1906. The main shock was felt over a land area of about 12,000 square miles and had a maximum Mercalli intensity of VII near the epicenter. In the southwest section of San Francisco, the highway skirting the south edge of Lake Merced cracked and sloughed off into the water. Both ends of a 200-foot-long pedestrian bridge collapsed. Glass broke in more than 400 street lights. Motorists on the Bayshore Highway said cars were shaken with a shuddering, sidewise motion. Approximately 1,100 reports were received from all sections of San Francisco. Many frightened people left downtown office buildings as chimneys crumbled, windows broke, and walls cracked around them.

"I've felt many earthquakes, but that one was the most severe I've ever experienced," she comments.

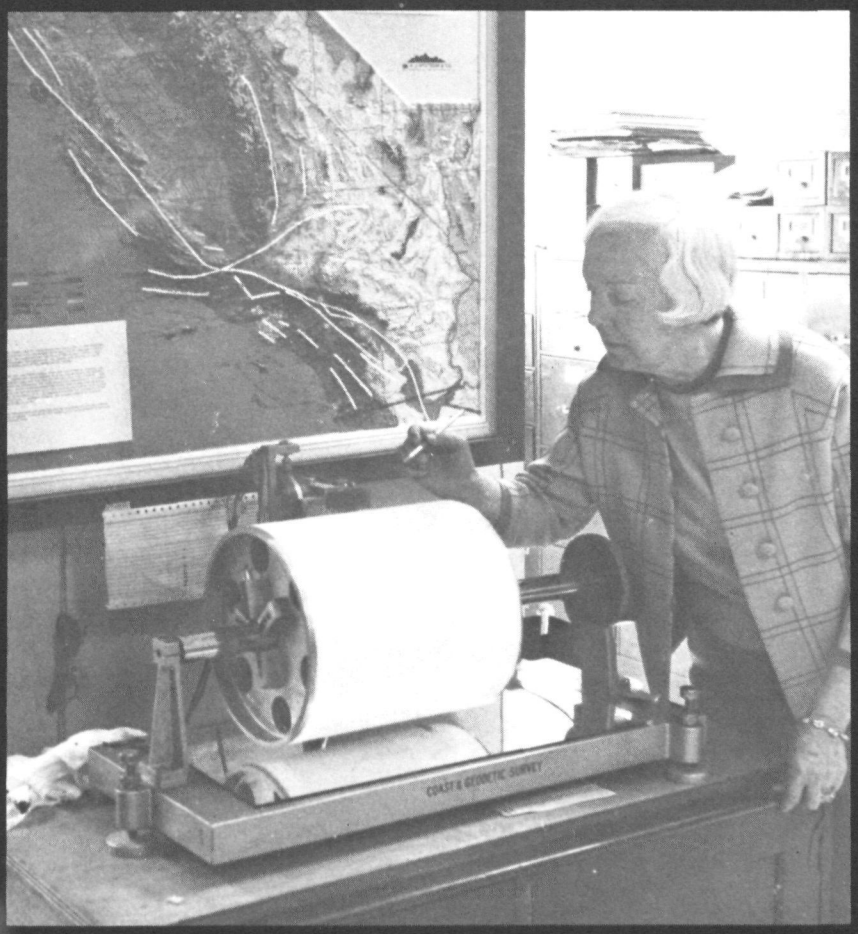
Mrs. Scott has had her office transplanted twice since. From the Old Mint she moved to the New Mint, and for the past seven years she has been working at her present location.

"The general public is well acquainted with our office here in San Francisco," she says. "I receive calls quite often from those who want to know if an earthquake has occurred." Mrs. Scott then checks around and makes every effort to let the person know if an earthquake has been recorded.

Born in Enid, Oklahoma, 64 years ago, Mrs. Scott has lived in San Francisco since she was 18 years old. She owns her own home and commutes to work in one hour by bus from the urban Twin Peaks area. When the grandmother of seven isn't working, she is busy cooking and keeping house.

"I love to cook, especially meats and sauces, but not many pastries or baked goods since I must watch my weight," she laughs.

What about retirement? Mrs. Scott plans to keep active—as a homemaker—and plans to stay in San Francisco, deep in the heart of earthquake country. □



(Top) After Nina Scott has rated earthquake intensities, they appear on published maps of seismicity. (Right) Mrs. Scott checks the seismograph in the Earthquake Mechanism Laboratory.

Leaders from government, universities, and industry will gather at Seattle, Washington, in July for

a fresh look at the oceans

Federal and state officials, labor and industry leaders, futurists and environmentalists will gather in Seattle next July for a three-day conference on economic development of ocean resources between now and the end of the century. Sponsored by NOAA, the gathering—whose title is "The Oceans and National Economic Development"—will take a fresh look at the ocean's potential for meeting national economic and social needs.

"The objective of this conference is to lay a basis on which NOAA and other government agencies can plan the future of the nation's oceanographic effort," said Dr. Robert M. White, NOAA Administrator, in announcing the conference. Using the full potential of the oceans in an environmentally sound way, he emphasized, is the challenge to which conference participants will address themselves. The conference will be built around six sessions, each dealing with a specific ocean-related topic. Keynote, luncheon, and banquet speeches will deal with various broad policy aspects of ocean development. The topics of the six sessions are—

The Ocean's Energy and Mineral Resources

The Ocean's Living Resources

The Oceans as a Recreational Resource

Coastal Zone Management and Marine Resource Development

Regional Organizations and Economic Development of Marine Resources

Marine Transportation's Role in Meeting Energy Needs

As presently planned, each of the sessions will be structured so that, following introductory remarks by the session chairman, speakers will address the topic in terms of broad national needs together with an overview of the approach, or approaches, necessary to meet those national needs. Experts will then discuss special aspects of the overall session topic. Open discussion periods will provide opportunities for speakers, panelists, and conferees to exchange views.

Tuesday, July 17, is the opening day of the conference. Governor Daniel J. Evans of the State of Washington and Mayor Wesley C. Uhlman of the city of Seattle will welcome the participants to the city, located on beautiful Puget Sound within sight of Mt. Rainier and the Cascade Range. The keynote speech on the importance of the oceans to the economic development of the nation will be delivered by Senator Warren G. Magnuson of Washington, Chairman of the Senate Commerce Committee.

The general morning session will also feature an address on "Our National Ocean Goals," and Dr. Athelstan Spilhaus of the Woodrow Wilson International Center for Scholars will give a futurist's look at the role of the oceans in economic and social development.

The morning session will be followed by a luncheon at which Senator E. F. Hollings of South Carolina will speak on the need for a national ocean policy.

The first full session, on the afternoon of July 17, addresses the critical area of the ocean's energy and mineral resources and their role in national economic development. The first principal address of this session will be delivered by Secretary of the Interior Rogers Morton. He will provide an appraisal of the national needs and an assessment of the proper role of government. He will be followed by two principal speakers, one assessing the energy situation from the petroleum industry's point of view and the second assessing the hard mineral situation from industry's point of view. These speeches will be delivered by senior executives in the petroleum and ocean mining industries. The addresses will be followed by panel discussion.

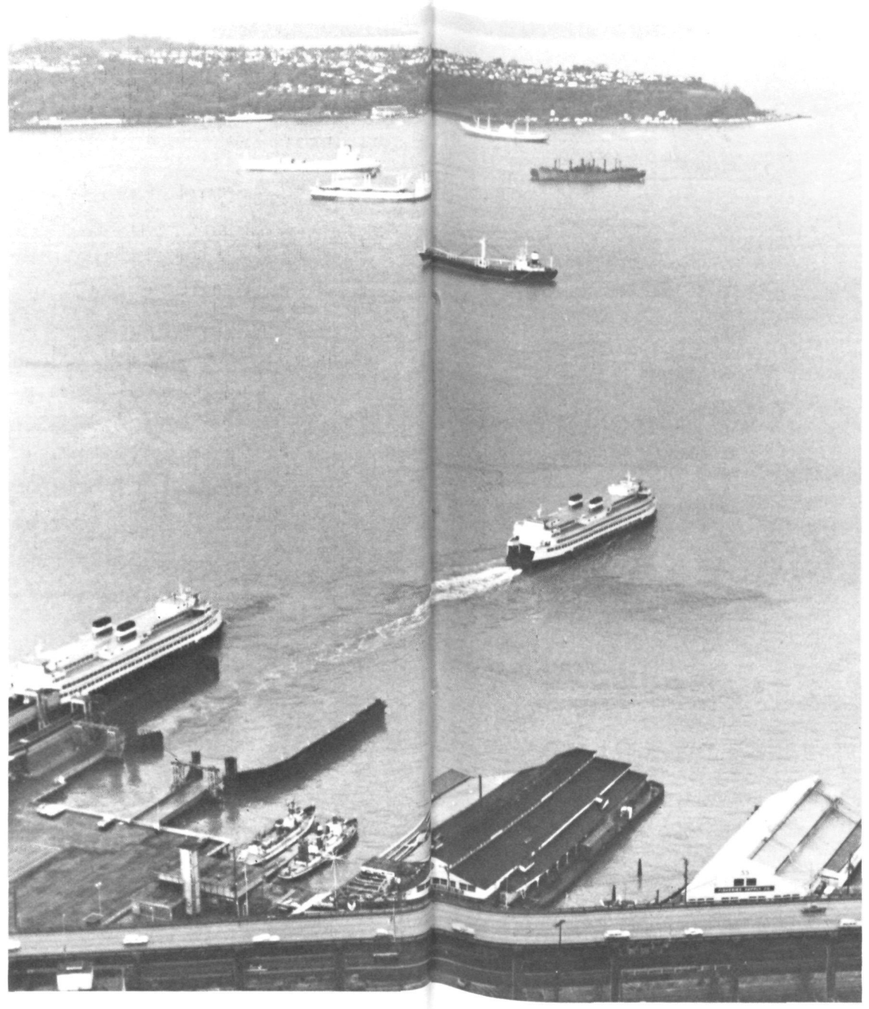
On Wednesday, July 18, the conference will cover the important topics of the ocean's living resources and the ocean as a recreational resource. As in the previous session, opening addresses will be delivered by leaders from government and industry. The recreational session will have two principal addresses: one by Assistant Secretary of the Interior Nathaniel P. Reed, discussing the critical role of the ocean as a recreational resource; the second, to be delivered by Raymond Sherwin, President of the Sierra Club, providing an assessment of the adequacy of government programs in meeting recognized requirements. A panel made up of state, industrial, and academic interests will further discuss the problem.

At the reception and banquet scheduled for that evening, Secretary of Commerce Frederick B. Dent will express his views on the oceans and industry.

The final day of the conference will cover coastal zone management, regional organizations and economic development, and marine transportation's role in meeting energy needs. Included among the participants for these three sessions are Dr. Betsy Ancker-Johnson, Academic/Science Advisor, Boeing Corporation; Howard Pollock, Deputy Administrator of NOAA; Rear Admiral J. J. McClelland, Chairman, Sea Use Council; D. E. Skinner, President of the Seattle-King County Economic Development Council; Dr. Robert W. Stewart, Director, Pacific Region, Environment Canada; Marvin Pitkin, Assistant Administrator for Research and Development, Maritime Administration; and R. J. Blackwell, Assistant Secretary for Maritime Affairs, Maritime Administration.

The program for the conference has been developed in conjunction with the National Science Foundation, the Office of the Oceanographer of the Navy, the Maritime Administration, and other groups concerned with marine resource development. Local arrangements are being made by the Sea Use Council and the Seattle-King County Economic Development Council which will host the conference in Seattle. The Marine Technology Society has provided both technical and program advice to NOAA.

Special events are being planned in addition to the conference that will allow conferees to visit oceanographic activities in the Seattle area. Activities will also be offered for wives of participants during the conference. □



AMONG THE SPEAKERS

Acceptances have continued to come into NOAA by noted individuals invited to speak at the Seattle Conference. Since the conference article was prepared, the following persons, among others, have indicated that they will attend and present papers:

Thomas Barrow, Senior Vice President, Exxon

Senator Henry Jackson of Washington

Harold Lokken, Manager, Fishing Vessel Owners Association, Inc.

Francis T. Christy, Jr., Resources for the Future

Dr. Beatrice Willard, Council for Environmental Quality

Ray Arnett, Director, Department of Fish and Game, State of California

Senator Ted Stevens of Alaska

Dr. John Craven, University of Hawaii

Charles Baird, Senior Vice President, International Nickel

Dr. Niels Rorholm, University of Rhode Island

Senator Mark Hatfield of Oregon

. . . and numerous others, truly a gathering of the top leaders in America's oceanic enterprises.

(Top) Downtown Seattle, with the Space Needle in the foreground. (Bottom) The city's waterfront is alive with activity. Shipping from all points on the globe frequents the deep-water harbor called Elliott Bay.

Because man is a creature of earth, special safety precautions are in order when he takes to the sea for recreation.

CAUTION: WATER AHEAD

Early Egyptian wall reliefs depict the story of the rout of the Hittites by Rameses II across the Orontes River in northern Syria. In one relief showing the battle which took place near Kadesh about 1300 B.C., the Hittites' King Aleppo is the unhappy subject of what is perhaps the earliest illustration of aquatic lifesaving methods. His Majesty, apparently having shipped an uncomfortable amount of Orontes River water, is being held by the ankles, head downward, to hasten his recovery.

As warm weather approaches, a surprising number of Americans will find that, while lifesaving techniques have been greatly improved, for many help will be too late or inadequate.

Drownings occur in frightening numbers each year—enough to make them the fourth highest cause of accidental deaths, behind automobile fatalities and deaths from falls and burns. Add to this the deaths and injuries caused by other water-related accidents such as boating mishaps, and a grim total emerges which make the water seem an inhospitable clime indeed.

But in spite of these statistics, water sports remain the nation's most popular outdoor pastime. Water—whether the vast Pacific or a tiny fishing stream—is the most easily accessible recreation facility to virtually every American. Millions of people each year spend some time either on, in, under, or around the water. (Almost 45 million are engaged in boating activity alone.)

As the boating and swimming season gets underway in many areas of the country, NOAA offers the following safety tips in the hope that they will make for a safer and happier vacation season. The information has been gathered from a number of sources including the U.S. Coast Guard, the American Red Cross, and reference books in the various subject areas. The reader is urged to seek out more detailed information on water safety than can be given in this limited space.

Swimming Safety

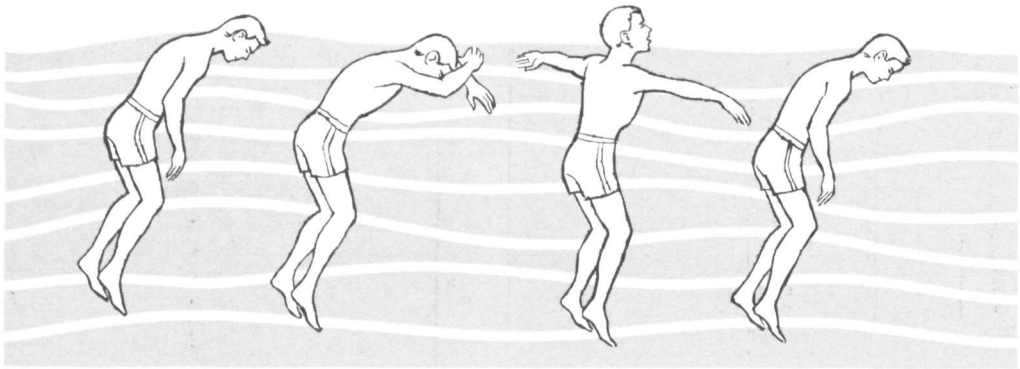
Many swimming fatalities are the result of negligence, such as failure to make sure the water is deep enough for diving and nonswimmers falling into the water from a dock or boat. In addition, many supposedly good swimmers lose their lives every year.

As in all sports, in swimming there are certain tricks and shortcuts to enable you to conserve energy and pace yourself if you find yourself in trouble. It's a good idea for you and your whole family, even if you think you're already pretty good swimmers, to take a course from the experts—the Red Cross-trained "pros" at your local swimming pool. Not only can you learn basic and advanced swimming techniques, but also first aid and life savings—invaluable knowledge for anyone on or near the water.

Good general rules for swimmers are:

Know your limits. Few of us are in the channel-swimmer class. Limit the length of time you spend in the water. The brisk, cold dip feels refreshing, but after only a few minutes it's bound to tire and weaken you. Even comfortable water in the 70 degrees range starts to cool down your body temperature after a while. Two one-hour stretches in the water—one in the morning and one in the afternoon—should be tops, and then only if the water feels warm. Don't forget the rule that to avoid cramps you should stay out of the water for about an hour after eating.

Drownproofing



There is a method of floating to safety for use by both swimmers and non-swimmers which is easily mastered and could save your life. The system, devised and named for Fred R. Lanoue, is predicated on the principles that ninety-nine out of one hundred people will float if their lungs are filled with air, and that you should float not horizontally, but almost vertically, if you keep your body fairly relaxed and limp.

Practice this system in water about five feet deep for adults, less for children. Here's the step-by-step procedure:

1. Stand with your feet on the bottom, breathe deeply, hold it, and put your face below the water's surface with just the back of your head out of water. Practice holding your breath under water like this as long as you can; then, still under water, exhale through your nose. Lift your head from the water, inhale deeply, and duck under again. When you have this inhale-down, exhale-up technique mastered, move to deeper water to practice.

2. Take a deep breath, duck under water, and lift your feet from the bottom. You will float (really!) in an almost upright position. Keep yourself in a limp and slouching position, feet down, arms at your sides, mouth and nose under water—as in exercise one.

3. In a few seconds, exhale through your nose under water.

4. Lift your arms slowly, bringing them in front of your face.

5. With some strength, extend your arms sideways and slightly downward. This will lift your body slightly—just enough to bring your mouth, now upturned, out of the water.

6. Take a deep gulp of air, meanwhile lowering your arms to your sides in a limp position again.

7. Lower your head under water and float until you feel you have to breathe again. Then repeat. Take about ten seconds between breaths, once you've mastered this routine.

That's it. Practice until you gain confidence; then begin tilting your body more and more to the horizontal between breaths, point yourself toward the edge of the pool or shore, and every now and then give a frog or scissors kick. You'll find yourself moving to safety. When you tire, just lower your legs on the vertical, and continue the Lanoue drownproofing system.

Know the waters. Don't dive from rocks, piers, or boats unless you *know* the water is deep enough. Avoid barnacle-encrusted rocks. Stay alert for boats, as you are difficult for them to see in the water. Watch out for rip currents; if caught in one, swim steadily at right angles to the direction in which you are being carried until you are out of danger, then swim to shore.

Non-swimmers can have safe fun on or near the water, too. These people, however, must take extra precautions.

In a boat, Coast Guard-approved flotation devices should be worn at all times by non-swimmers, elderly persons, small children, and invalids.

Artificial Respiration

In attempting to revive an apparently drowned person, the patient's mouth should first be cleared of any obstruction, such as chewing gum, tobacco, or mucus, so there is no interference with the entrance or escape of air to or from the lungs.

Artificial respiration should be started immediately. Every moment of delay is serious. It should be continued at least four hours without interruption, until normal breathing is established, or until the patient is pronounced dead by a medical officer.

The victim's clothing should be loosened, and he should be kept warm. However, this cannot be allowed to interrupt the administering of artificial respiration.

Frequently the patient, after a temporary recovery of respiration, stops breathing again. The patient must be watched and if natural beathing stops, artificial respiration should be resumed at once.

In mouth-to-mouth artificial respiration, the procedure is as follows:

1. Place the unconscious victim on his back, as you must be able to see his face.

2. Move an injured victim cautiously.

3. If there is foreign matter visible at the mouth, turn his head to the side, force his mouth open and quickly clean the mouth and throat with your fingers or a piece of cloth.

4. Place the victim's head in the "sniffing position" placing the head as far back as possible so that his neck is extended, and hold his lower jaw upward so that it "juts out" (it is most important that the jaw be held in this position).

5. Hold the jaw in this position in one hand, approach the victim's head from his left side.

6. Insert the thumb of your left hand between the victim's teeth and grasp his lower jaw at the midline.

7. Lift the lower jaw forcefully upward so that the lower teeth are higher than the upper teeth.

8. Hold the jaw in this position as long as the victim is unconscious.

9. Close the victim's nose with your right hand.

10. After taking a deep breath, place your mouth over the victim's mouth, *with airtight contact.* Do not hold the victim's mouth open widely, as you must take the entire mouth of the victim inside your lips.

11. Blow into the victim's mouth, forcefully if adults and gently if children.

12. While blowing, watch the victim's chest. When the chest rises, stop blowing and quickly remove your mouth from the victim's mouth.

13. Let the victim exhale passively by the elasticity of his lungs and chest.

14. When the chest does not rise improve the support of the air passageway and blow more forcefully.

15. Repeat these inflations 12 to 30 times per minute.

Boating Safety

Now hear this! According to the U.S. Coast Guard, over half of the boats that got into an accident did so by smashing into another boat or some immovable object. If you think that's bad news—then consider the fact that most of these accidents happened because the operator of the boat *wasn't even looking ahead!* It would seem that these people, from the time they stepped into their boats were no better than an accident going somewhere to happen. In other cases, the operator was looking ahead but he didn't know what to do.

In boating, as with swimming on and under the water, the best course is to take instruction from experts. Courses in all aspects of pleasure-boat operations are available from the Coast Guard Auxiliary, and small-craft schools are operated in many areas by the American Red Cross.

Some safety tips for small boat operators:

Keep the passengers in your boat down to a safe number; don't overload.

Don't overpower your boat. Your dealer will tell you what size motor is best for your particular boat.

Equip your boat with safety items. Proper lights (if you plan to be out at night) and Coast Guard-approved lifesaving gear are musts. Also, an anchor, oars, a boat hook, extra line, a fire extinguisher, a tool kit, and a first aid kit are recommended.

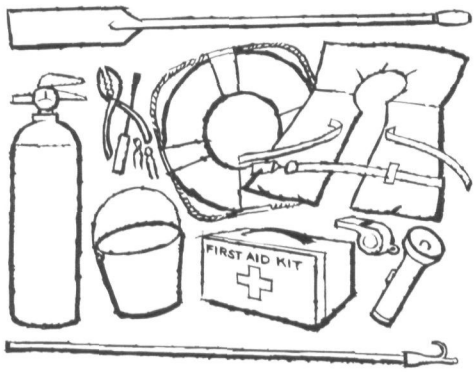
Never smoke while fueling.

If your boat overturns, hang on until help comes, unless the boat is drifting into danger or the water is extremely cold—then swim for safety, conserving your energy as best you can.

Learn boating "rules of the road."

Practice courtesy afloat.

Check National Weather Service forecasts before venturing into open water; take along National Ocean Survey nautical charts.



Underwater Safety

In skin diving, the greatest danger to the diver isn't sharks, moray eels, or entangling kelp beds. The greatest danger is man himself. In the unnatural underwater environment, man experiences a certain disorientation during which he can make totally wrong assumptions that can result in foolhardy actions, panic, and death.

Most important to the skin diver is proper equipment, proper instruction, and proper attitude.

As with flying an airplane, a certain amount of self-instruction is possible in skin diving, but you should never start your underwater experience without the assistance of a trained diver/instructor. There is a whole new set of safety rules involved, not associated with the air-breathing world.

Try a Different Seafood

Of all the fish in the sea, Americans have tended to prefer, and purchase, relatively few varieties.

Some species may have been neglected because of their appearance; others, simply because they are unfamiliar. Many have not been available in commercial quantities, because of difficulties in harvesting or processing.

To promote increased use of available resources, the National Marine Fisheries Service encourages the development of new fisheries, better harvesting methods, and improved processing techniques.

NMFS consumer specialists were on hand at the National Canners Association convention this year to interest the industry in packaging and marketing such underutilized seafoods as pollock, whiting, and mullet, and specially the geoduck clam, ocean quahog, Jonah crab, squid, Atlantic croaker, and sunray venus clam.

The geoduck—pronounced "gooey-duck"—is the most impressive clam in United States waters and is believed to be second in size only to the giant clam found in the East Indies. The largest geoduck ever found weighed 13 pounds. The average clam weighs three pounds and yields 1½ pounds of meat. Its shell is far too small to contain the entire clam.

Although geoducks are found all along the U.S. west coast, they are most abundant in Washington's Puget Sound. These giant clams live in mud, sand, small gravel, or a mixture of these, from 18 inches to six feet below the surface of the beach or, if underwater, beneath the surface of the bottom. Commercial harvesting is done by divers.

Geoduck meat is juicy, rich, and of fine flavor. Enthusiasts say that geoduck steak compares in taste and texture to abalone, but is sweeter. These clams are sold in numerous market forms including frozen breast and neck steaks, frozen and canned minced meats, frozen and canned chunks, and canned smoked chunks. They are also available fresh upon request. The steaks can be served pan-fried or grilled, the minced clamp in a dip or chowder, and the canned chunks and smoked canned chunks as party snacks.

If the clams are purchased fresh, dipping them into hot water will open up the shell and loosen the skin. The skin and stomach are discarded, and at this point the clams should be washed thoroughly, and rinsed in cold water. It is possible to cut three steaks off one geoduck: one from the breast and two from the neck. These are best breaded and fried. The remaining meat can be ground and used for chowder.

The Atlantic croaker gets its name from the drumming croak it produces at various times. This croaking increases during the spawning season, and is also heard when the fish is touched or pursued. Harvested principally in the Gulf of Mexico, and to some extent in the Chesapeake Bay, croakers can be more than a foot long at maturity and weigh from one to four pounds.

Croaker is an excellent pan fish with high food value. With its 17 percent protein, a three-ounce serving provides nearly 25 percent of the recommended daily amount for adults. It is exceptionally high in potassium, a vital trace element. When pan-fried, it is tender and has a mild, sweet flavor. Croaker is available in a variety of sizes from half-pound to three pounds, making it suitable for many serving sizes and methods of preparation. It is moderately priced and available either fresh as it comes from the sea or frozen pan-ready.

NMFS consumer specialists Doris Robinson and Arleen Joyce prepared and served under-utilized seafoods at the Canners' Convention.

The Jonah crab ranges from Nova Scotia to the South Atlantic states, but is most abundant off the New England and Middle Atlantic coasts. It has a broad, coarse, oval carapace which is brick red to purplish in color or top and yellowish underneath. The larger crabs are about six inches wide and weigh an average of one pound with some specimens reaching 1¾ pounds. The crushing claws of the Jonah crab are moderately large. It is a walking crab, not a swimmer, so it doesn't have the lump meat of the swimming crabs; instead, the claws of the Jonah are more developed, and the biggest pieces of meat are the claw meat chunks.

Jonah crab meat is presently packaged in six or seven-ounce see-through jars with the chunky leg meat on top, and the body meat, in smaller pieces, on the bottom.

Formerly thought to be strictly a European species, the ocean quahog today is known to range from the Arctic Ocean to Cape Hatteras, N.C. Though ocean quahogs are found in depths of about six to 90 fathoms (one fathom is six feet), the best catches are made at depths of 18 to 24 fathoms. Along the New England coast, the ocean quahog fishery is expanding, with the clams being harvested with a hydraulic sea clam dredge.

The average quahog is 3½ to 4 inches long and weighs a half pound. Since it is darker in color and has a stronger flavor than other clams, recipes have been developed to take advantage of these characteristics.

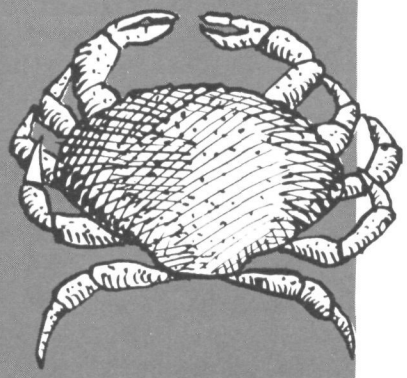
Most of the domestic catch of squid is a small, edible variety taken off Southern California. They also occur on the Atlantic and gulf coasts, and on the west coast from Baja California to the southern tip of Vancouver Island.

In this country, the value of squid as food has never been fully realized, and it is considered an underharvested resource. Squid is considered a gourmet or specialty item and has long been popular with Mediterranean, Oriental, and Mexican cooks. It has a delicate flavor and is delicious when fried or baked with a stuffing and may also be used in salads, sauces, or combination dishes. Whole squid is available fresh in some areas and frozen in most areas.

The sunray venus clam, found from South Carolina to Florida and the gulf states, is popular with shell collectors. Elongated and glossy-smooth, the shells are dull pink to bluish purple in color, with broken radial bands of darker color. Mature sunrays are five to seven inches long. Commercial harvesting began in 1956, and presently the largest producing sunray venus clam bed is in Florida off Port St. Joseph. Its meat is of high quality and readily useable in chowders, fritters, patties, dips, and clam loaf.

The following recipes for underutilized species were developed by the NMFS National Marketing Services Office.

Sea Fare



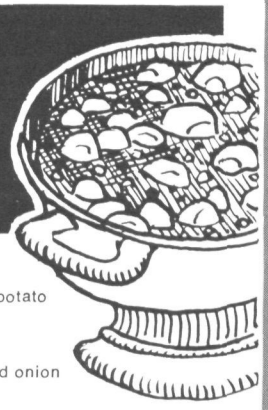
Cheese-Crab Fondue

8 ounces crabmeat
1 can (10 ounces) condensed cream of shrimp soup
¼ cup milk or half & half cream
½ cup shredded process American or cheddar cheese
2 teaspoons lemon juice
Dash paprika
Dash white pepper
2 tablespoons sherry, optional

Remove any remaining shell or cartilage from crabmeat. Combine cream of shrimp soup with milk in fondue pot. Cover, heat over direct moderate flame, stirring often. Fold in remaining ingredients except sherry. Adjust heat to low flame. If desired, stir in sherry just before serving.

Use as an appetizer with Melba toast or as a luncheon dish on toast points or in patty shells. Add milk if a thinner mixture is desired. Makes approximately 2¾ cups.

CROAKER CAN-CAN CHOWDER



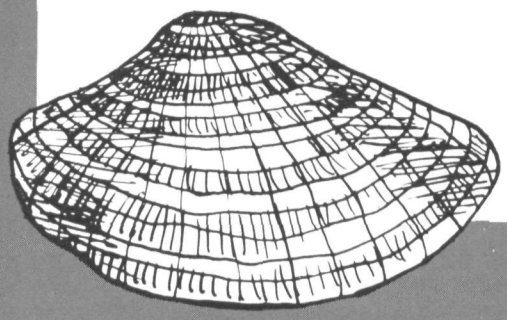
3 cups flaked croaker
2 (10½ ounce) cans cream of potato soup
3 cups milk
2 tablespoons margarine
2 teaspoons dehydrated minced onion
1 small bay leaf
⅛ teaspoon pepper
1 (12 ounce) can corn and peppers
Paprika

Combine soup, milk, margarine, onion, bay leaf, and pepper. Heat until hot, stirring occasionally. Add corn and fish; heat. Remove bay leaf. Garnish with paprika. Makes 6 servings.

HOT SUN-RAY VENUS CLAM DIP

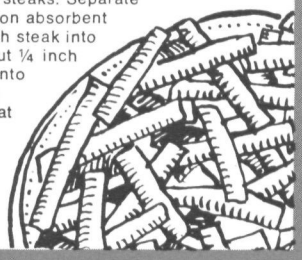
2½ pounds minced clams, fresh or frozen
½ cup margarine
¾ cup chopped onion
3 tablespoons flour
¼ cup chopped green pepper
¼ teaspoon salt
⅛ teaspoon pepper
1 cup clam liquor
1 cup grated American cheese
1 (8 ounce) jar pasteurized process cheese spread
2 tablespoons chopped pimiento
¼ cup chili sauce
1 teaspoon Worcestershire sauce
½ teaspoon liquid hot pepper sauce
Corn chips

Thaw frozen clams. Cook in natural liquor for 4 to 5 minutes or until clams are done. Drain. Reserve liquor. Saute onion and green pepper in margarine until tender. Blend in flour, salt and pepper. Add clam liquor gradually and cook over moderate heat until sauce is thick, stirring constantly. Add grated cheese and pasteurized process cheese spread and continue to heat until cheese melts. Add pimiento, chili sauce, Worcestershire, liquid hot pepper sauce, and clams. Heat. Serve hot with corn chips. Makes 4½ cups dip.



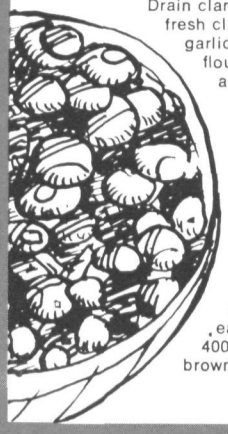
KING CLAM TEASERS

Thaw frozen geoduck steaks. Separate each steak and drain on absorbent paper towels. Cut each steak into lengthwise strips about ¼ inch thick. Cut each strip into thirds. Roll strips into pancake flour. Deep fat fry at 350°F., until golden brown. Serve with seafood sauce.



Deviled Quahogs

1 pint shucked clams or 2 (8-ounce) cans minced clams
½ cup chopped celery
2 tablespoons chopped onion
1 clove garlic, finely chopped
¼ cup melted fat or oil
1 tablespoon flour
1 tablespoon chili sauce
½ teaspoon salt
¼ teaspoon pepper
¼ teaspoon thyme
3 drops liquid hot pepper sauce
1 egg, beaten
½ cup cracker meal
2 tablespoons chopped parsley
½ cup dry bread crumbs
2 tablespoons melted fat or oil



Drain clams and reserve liquor. Chop fresh clams. Cook celery, onion, and garlic in fat until tender. Blend in flour and seasonings. Add clams and cook until thick, stirring constantly. Stir a little of the hot sauce into the egg, add to remaining sauce, stirring constantly. Add cracker meal and parsley. If necessary to moisten, add small amount of clam liquor. Fill small, well-greased individual seafood shells with approximately 2 tablespoons clam mixture. Combine crumbs and fat; sprinkle over top of each shell. Bake in hot oven, 400°F., for 10 minutes or until brown. 36 hors d' oeuvres.

Cioppino -a Fish Stew

¼ cup olive oil or salad oil
1 medium onion, finely chopped
1 clove garlic, minced
1 (1 pound 12 ounce) can tomatoes
2 (8 ounce each) cans tomato sauce
2 (1½ ounce each) packages spaghetti sauce mix
1 teaspoon seasoned salt
¼ teaspoon seasoned salt and pepper
2 cups water
1 cup dry white wine (optional)
1½ pounds rockfish, cut in large chunks
1 dozen squid cleaned without tentacles and quill

Heat oil in large Dutch oven or kettle on medium heat. Add onion and garlic and cook until tender. Add tomatoes, tomato sauce, spaghetti sauce mix, seasoned salt, seasoned pepper, and water. Cover pan. Bring to boil on high heat; switch to a low heat and simmer 30 minutes, stirring occasionally. Add wine, rockfish, and squid. Cover and simmer about 15 minutes, stirring occasionally. Serve in large bowls with chunks of heated French bread. Makes approximately 6 servings.

JONAH CRAB CRUNCH

1 pound Jonah crabmeat fresh or frozen
1 can (8¾ ounces) crushed pineapple
3 tablespoons butter or margarine
½ cup thinly sliced celery
2 tablespoons cornstarch
2 cups chicken broth
½ cup toasted blanched slivered almonds
1 tablespoon lemon juice
1 can (5 ounces) chow mein noodles

Thaw frozen crabmeat. Drain crabmeat. Remove any remaining shell or cartilage. Drain pineapple, reserving liquid. Melt butter in a 10-inch fry pan. Add celery, pineapple, and crabmeat. Cook over low heat for 5 minutes, stirring frequently. Dissolve cornstarch in pineapple juice. Stir into crab mixture. Add chicken broth gradually and cook until thick, stirring constantly. Add almonds and lemon juice. Serve over noodles. Makes 6 servings.

MULLET MEXICANA

2 pounds mullet fillets, or other fish fillets fresh or frozen
⅔ cup dry bread crumbs
⅓ cup butter or margarine, melted
¼ cup grated onion
1 teaspoon chili powder
1 teaspoon salt
¼ teaspoon ground thyme
Dash cayenne pepper
Paprika
Lemon wedges

Thaw frozen fillets. Place fillets in a single layer, skin side down, on a well-greased bake and serve platter, 16 x 10 inches. Combine remaining ingredients except paprika and lemon wedges. Spread crumb mixture over fillets. Sprinkle with paprika. Bake in a moderate oven, 350° F., for 20 to 25 minutes or until fillets flake easily when tested with a fork. Serve with lemon wedges. Makes 6 servings.

TANGY SQUID SALAD

2 pounds whole squid, fresh or frozen
Boiling water
1 cup sliced celery
1 cup sliced onion, red or white
1 cup coarsely shredded carrot
½ cup salad or olive oil
⅓ cup lemon juice
1 tablespoon chopped parsley
1 teaspoon oregano
½ teaspoon salt
1 clove garlic, sliced
4 to 6 tomatoes or avocado halves

Thaw frozen squid. To clean squid, grasp head and mantle (body) firmly in hands; pull off head, tentacles, and ink sack. Pull transparent backbone or quill from the mantle. Squeeze any remaining entrails from inside mantle. Under cold running water, peel off speckled membrane covering mantle. Wash mantle thoroughly, inside and out. Slice mantle crosswise into ½-inch rings. Drop sliced squid into boiling water to cover and simmer for 20 minutes or until cooked. Drain. Place celery, onion, carrot, and drained squid in bowl. Combine oil, lemon juice, parsley, oregano, salt, and garlic; mix. Pour oil mixture over ingredients in bowl; mix well. Cover; chill several hours or overnight. Remove garlic. Serve on tomatoes, cut top to bottom into eights, not quite through, or on avocado halves, as desired. Makes about 4 cups of salad mixture, 4 to 6 servings.

ALOHA SEAFOOD FOR DIETERS

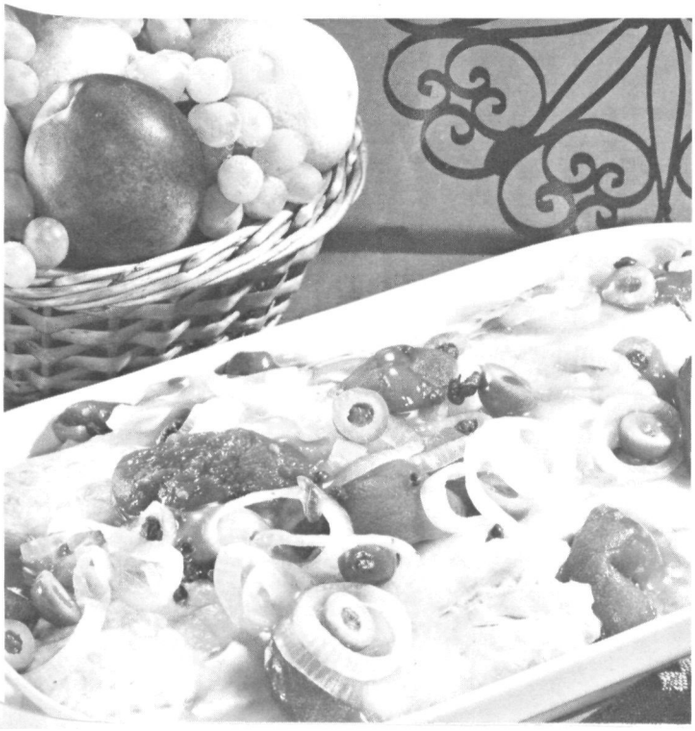
2 pounds mullet or other fish fillets, fresh or frozen
½ cup pineapple juice
¼ cup steak sauce
1 teaspoon salt
Dash pepper

Thaw frozen fillets. Skin fillets and cut into serving-size portions. Place fish in a single layer in a shallow baking dish. Combine remaining ingredients and pour over fish. Let stand for 30 minutes, turning once. Remove fish, reserving sauce for basting. Place fish on a well-greased broiler pan. Broil about 4 inches from source of heat for 4 to 6 minutes. Turn carefully and brush with sauce. Broil 4 to 6 minutes longer or until fish flakes easily when tested with a fork. Makes 6 servings.

FLAKY WHITING

(Approximately 80 calories in each serving.)
3 pounds pan-dressed whiting or other pan-dressed fish, fresh or frozen
1 teaspoon salt
Dash pepper
1 cup instant mashed potato flakes
1 package (7/10 ounce) cheese-garlic salad dressing mix
½ teaspoon salt
Dash pepper
1 egg, beaten
¼ cup butter or margarine melted
Paprika

Thaw frozen fish. Clean, wash, and dry fish. Sprinkle inside with salt and pepper. Combine potato flakes, salad dressing mix, salt, and pepper. Dip fish in egg and roll in potato flakes. Place in a single layer on a well-greased bake and serve platter, 16 x 10 inches. Pour butter over fish. Sprinkle with paprika. Bake in an extremely hot oven, 500° F., for 15 to 20 minutes or until fish flake easily when tested with a fork. Makes 6 servings.



PACIFIC SNAPPER WITH SPICY TOMATO SAUCE

2 pounds red snapper or other fish fillets, fresh or frozen
¼ cup olive or cooking oil
2 tablespoons lemon or lime juice
1½ teaspoons salt
2 cups sliced onion
1 clove garlic, minced
1 can (1 pound) tomatoes
½ teaspoon sugar
¼ teaspoon cinnamon
⅛ teaspoon cloves
½ cup stuffed olive halves
2 tablespoons drained capers (optional)
Jalapeno chilies (optional)

Thaw frozen fish. Spread 1 tablespoon oil over bottom of shallow 2-quart baking dish; arrange fish in dish. Drizzle with lemon or lime juice. Cover; refrigerate about ½ hour. Uncover; sprinkle with 1 teaspoon salt. Bake in moderate oven, 350° F., 30 minutes or until fish flakes easily when tested with a fork. Baste with juices several times during baking. While fish is cooking, prepare sauce. Cook onion and garlic in remaining 3 tablespoons oil until tender, not brown. Add tomatoes, remaining ½ teaspoon salt, sugar, cinnamon, and cloves. Simmer uncovered 15 to 20 minutes or until flavors are blended and sauce is thickened. Stir in olives, and capers, if desired. Serve sauce over fish and garnish with Jalapeno chilies cut into strips (optional). Makes 6 servings.

MARMAP Surveys Find Oil, Plastic Contaminate Waters off U.S. Coast

Data gathered during three cruises of NOAA ships has revealed that oil globules and plastic debris in epidemic proportions infect nearly 700,000 square miles of blue water from Cape Cod to the Caribbean Sea, becoming part of the habitat of uncountable numbers of newborn blue marlin, tuna, bluefish, and other prized game and commercial species.

While the presence of oil and plastic materials in ocean waters was already known, the survey found that they are distributed far more widely than had been suspected.

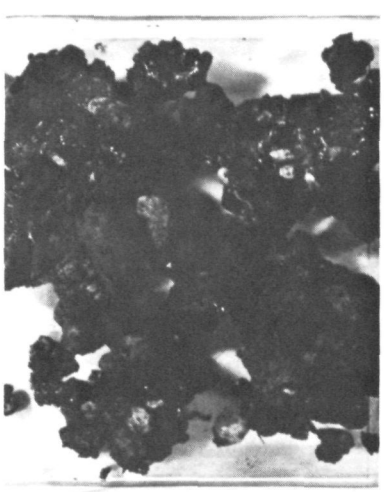
The ALBATROSS IV, DELAWARE II, and the OREGON II traversed a wide swath of continental waters from Massachusetts to Florida, east into the Sargasso Sea, around the Bahama Island chain, south along a track skirting the Venezuela coast, and west into the Gulf of Mexico. The cruises, made in July and August 1972 to assess distribution of fish eggs and larvae, constituted the first survey of MARMAP — Marine Resources Monitoring, Assessment, and Prediction—a National Marine Fisheries Service program to evaluate the living resources in waters off the shores of the United States.

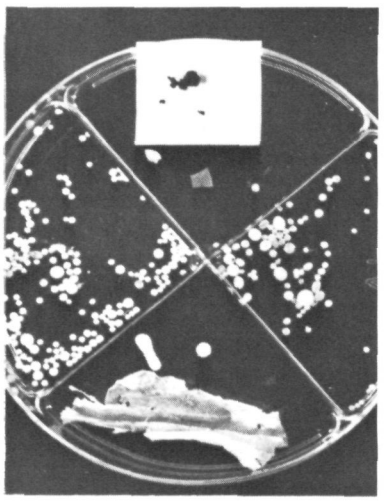
Oil contamination was detected in 665,000 square miles of open ocean. The ships' plankton-collecting nets became fouled by tar balls, from grain- to fist-sized, that appeared to have been formed from bunker oil jettisoned from ships, and by oil clumps so thick they extruded through the mesh "like spaghetti."

Subsequent laboratory analyses revealed that more than half the plankton samples (young fish and their food) collected from surface waters were oil-contaminated.

Plastic contaminants, though not as prevalent as the tar balls, were found in all survey regions. The plastic scraps were white or opaque spheres or discs, speck- to pea-sized, and were identified as polystyrene. Despite their small size, they may threaten the survival of many of the minuscule larval fish that consume them. Scientists at the Woods Hole Oceanographic Institution who examined larval fish with plastic in their digestive systems fear that, because of its indigestibility, the material may be dangerous.

It was cautioned that the MARMAP findings are not, in themselves, conclusive, and that the total environmental effect of these widespread contaminants in the ocean remains to be evaluated.





Samples of tar (left) and plastics (right) collected during MARMAP surveys of waters from Cape Cod to the Caribbean Sea.

Structural Response to Quakes Mapped by ERL Mathematician

Applying techniques similar to those used to analyze the voices of whales, dolphins, and sopranos, Virgilio Perez, a mathematician with the Environmental Research Laboratories' San Francisco-based Seismological Field Survey, is analyzing the chorus of responses given by structures subjected to earthquake vibrations. He used strong-motion data obtained during the February 1971 San Fernando, Calif., tremor to develop his improved data-analysis technique, which literally maps the types and duration of shaking experienced by structures in an earthquake.

According to Dr. R. B. Matthiesen, director of the Survey, "The present work clarifies the elusive concept of 'duration' of strong motion in earthquakes. Extensions of this work should provide the structural engineer with basic design information required to advance the state of earthquake-resistant structural design."

Mr. Perez prepared three-dimensional diagrams based on the Pacoima Dam strong-motion record, and charted the response "envelope" for each of 40 selected periods of oscillation, emphasizing the higher frequencies, which are more oscillatory. This calculation was made for intervals of one tenth of a second, producing a rectangular time-and-space grid of response values.

"The resulting 'topographic map' of response amplitude values shows the peaks and values of the velocity response spectrum as a function of time and period," Perez says, "with a maximum velocity response spectrum curve indicating the silhouette of these peaks."

Sea Grant Funds Production of Shell Derivative

The shells of shellfish, long considered waste by the seafood industry, are being salvaged to produce a cellulose-like substance of commercial value to a variety of industries.

Chitin (pronounced "kite-n") and its derivative, chitosan, are beng produced at a small pilot plant on the outskirts of Seattle, Wash., and offered to researchers who have already identified scores of known and potential uses for the product.

NOAA, through its Office of Sea Grant, has guaranteed the pilot plant a market by purchasing $48,000 worth of chitin and chitosan during 1972-1974.

The chitin-chitosan plant, operated by Food, Chemical, and Research Laboratories, Inc., of Seattle, was built in response to growing demands for alternate methods for the disposal of the thousands of tons of lobster, shrimp, and crab carcasses annually dumped in ocean and near-shore regions, a pollution problem as such material is highly resistant to biodegradation.

John Connolly Appointed to Aviation Post

John W. Connolly has been named Special Assistant for Aviation Affairs to NOAA's Administrator, Dr. Robert M. White.

In this post, Mr. Connolly will advise on aviation services, serve as NOAA's liaison with the Federal Aviation Administration, and represent NOAA to other government agencies, the aviation industry, and international interests, in matters concerning aviation.

Before his appointment to this post, he was assigned for eight months in the Executive Office of the President as Deputy for Operations in the New Technology Opportunities Program. Prior to that, he was chief of the Systems Division at NOAA headquarters.

Mr. Connolly received a bachelor's degree (1951) and a master's degree (1956) from Boston College. He served in the U.S. Air Force for 21 years, seven with the USAF Air Weather Service and the remainder in research and development assignments.

Tornado Preparedness Drive Opens; 1972 Toll Was Lowest on Record

With an announcement by NOAA's National Climatic Center that the 1972 U.S. tornado death toll was the lowest on record, the National Weather Service has launched SKYWARN '73, an annual effort to save lives through preparedness. Dr. George P. Cressman, Director of the NWS, in opening this year's campaign said, "Although I'm sure there are elements of luck and a measure of aid from nature in the low 1972 toll, I'm also confident that community preparedness has been a big factor in holding down tornado fatalities."

According to preliminary reports, 27 people were killed in tornado-related incidents in the U.S. in 1972. The long-term average is well over 100 deaths each year and in several years the death toll has exceeded 500.

The reduction in the number of deaths has occurred in the face an ever increasing number of reported tornadoes as well as an explosive growth in U.S. population.

Last year there were 744 tornadoes reported—85 more than the 659 yearly average in the past two decades. The 1972 tornado season was unusual in several respects. Very few of the outbreaks were of "family type"—the kind that leave long, wide paths of destruction.

The '72 season starkly demonstrated the point that no state is immune from tornadoes. The "tornado of the year" struck Vancouver, Washington on April 5 causing six deaths, 300 injuries and more than $5,000,000 in property damage. The fatalities were the first ever recorded in that state and the deaths in connection with the Vancouver storm were the greatest number in any state in 1972.

Weather Service officials are always uneasy about publicizing low storm tolls. They have had long experience in combating public apathy. Consequently they point out that there have been other years when death tolls were low—28 in 1962, 29 in 1937, and 31 in 1963—and several recent years when totals climbed above 150, although the general trend is downward. They add that even though 1972 deaths were a record low, it shouldn't be overlooked that there were 986 tornado injuries in 29 states, along with about $143 million in property damage. Only six states had not tornadoes during 1972.

The Weather Service launches SKYWARN in advance of the tornado season to encourage community leaders to activate preparedness plans, insure prompt dissemination of watches and warnings, and enlist the aid of the news media in publicizing ways that people can protect themselves against the violent storm. Realizing that the human eye remains the best and most reliable means of detecting tornadoes, an important part of the SKYWARN program concentrates on the recruitment of volunteer storm spotters.

Together with other Federal agencies and private organizations, the NWS is making a special effort to point out the vulnerability of mobile homes to high winds. Every year winds damage or destroy more than 5,000 mobile homes. More than six million Americans now live in mobile homes and one-fourth of all new homes being built in the U.S. are the mobile or manufactured home. Proper tie downs and use of community shelters in mobile home parks are advocated to prevent death and injuries and minimize damage.

Meetings with news media representatives in more than 40 selected cities in the U.S. have been held since the SKYWARN program was initiated. Allen Pearson, Director of the NSSFC, regional Weather Service officials, State Climatologists, NOAA public affairs officers, and Meteorologists in Charge discuss with broadcasting and newspaper representatives improved means of dissemination as well as public affairs and educational programs.

Annually public information material including brochures, posters, radio and television announcements and films receive wide distribution as part of SKYWARN.

Many other organizations including the Defense Civil Preparedness Agency, the American National Red Cross, and the Office of Emergency Preparedness have participated with NOAA at the national, state and local levels in the annual SKYWARN program.

Miami Lab Dedicated

Exterior view of the Atlantic Oceanographic and Meteorological Laboratories' new building on Virginia Key, near Miami, Florida.

The new $3.5 million Miami, Fla., home of the Atlantic Oceanographic and Meteorological Laboratories, one of the Environmental Research Laboratories, was formally dedicated February 9. The laboratory had been in the planning stage since 1967.

The five-story structure provides 74,000 square feet of modern laboratory space for research in physical oceanography, marine geology and geophysics, sea-air interaction, and satellite oceanography and remote sensing. In addition, it houses personnel from the Environmental Data Service, National Weather Service, and National Environmental Satellite Service engaged in ocean-related research.

It is part of a research complex that includes the University of Miami's Rosentiel School of Marine and Atmospheric Science and the Southeast Fisheries Center of the National Marine Fisheries Service.

Experimental Network To Monitor Tornadoes

NOAA is continuing its experimental deployment of electronic "tornado detectors" during the 1973 season, after obtaining positive results last year. The project is conducted by the Wave Propagation Laboratory, one of the Boulder, Colo.-based Environmental Research Laboratories, in conjunction with NOAA's National Weather Service and its National Severe Storms Forecast Center.

During the 1973 tornado season instruments will be located at National Weather Service stations in Amarillo, Lubbock, and Fort Worth (Carswell Air Force Base), Tex.; Oklahoma City and Tulsa, Okla.; Little Rock, Ark.; Memphis, Tenn.; Jackson, Miss.; Tampa, Fla.; Grand Island, Nebr.; Des Moines, Iowa; Topeka and Wichita, Kans.; and Springfield and St. Louis, Mo.

According to William L. Taylor, who leads the project for the Wave Propagation Laboratory, the instruments measure an electromagnetic "signature" of processes in cloud systems where tornadoes are likely to occur, rather than the presence of tornadoes themselves.

Preliminary data analysis indicated there were 542 electro-magnetic responses by the equipment during the 1972 season. These were correlated with the Severe Weather Reports from the National Severe Storms Forecast Center in Kansas City. Equipment responses which appeared to correspond to the severe storm activity within 70 kilometers of the instrument—41 tornadoes, 30 funnel clouds, 54 hail storms, 60 windstorms, and 507 local thunderstorms—were examined to measure whether, and how well, the method worked. The examination indicates that the instrument would have warned against 73 percent of the tornadoes. It would also have indicated about 40 percent of the funnel cloud storms as tornadic, and 27 percent of the hail and windstorms as possibly tornadic. Only 6.5 percent of the local thunderstorms would have produced false alarms.

"It should be emphasized," Mr. Taylor says, "that these results are preliminary and that a more complete analysis must wait for the full storm record when it becomes available from NOAA's Storm Data Publication."

Weather Service Changes Terms In Small Craft Alerting Messages

The National Weather Service has changed the terminology for the traditional announcement to small-craft operators of marginally hazardous weather conditions. Instead of "Small Craft Warnings," these weather messages are now called "Small Craft Advisories," to reflect more accurately the true nature of their content.

The NWS has an ascending series of alerting messages for mariners, keyed to increasingly hazardous weather. The lowest rung in the ladder has been the small-craft warning—for winds of about 18 to 33 knots and/or dangerous sea conditions. Next in urgency is the gale warning (for winds of 34 to 47 knots), then the storm warning (48 to 63 knots or more), and lastly, the hurricane warning (winds of 64 knots or more produced by a tropical cyclone).

All but the small-craft warning are based on well-defined meteorological conditions, and will remain the same. The small-craft warning is less precise, and varies in meaning from one locality to another. In response to objections from mariners about vagueness and variability, the Weather Service is switching to the word advisory, and informing mariners to decide for themselves whether the observed or forecast conditions constitute a real danger to them.

Along with this change in terminology, marine weather forecasters have begun to issue by radio a new warning that carries the label "Special Marine Warning Bulletin." No visual displays accompany the bulletin. It is issued whenever a severe local storm or strong wind of brief duration is imminent, and is not covered by existing warnings or advisories. Boaters will receive these special warnings if they keep tuned to a Weather Service VHF/FM or Coast Guard radio station, or to a commercial station that carries marine weather.

Study of S.E. Coastal Zone To Provide Planning Data

A concentrated two-year environmental study from the air, sea, and land has been launched in a 105,000-square-mile area of coastal waters off northern Florida, Georgia, South and North Carolina by the National Ocean Survey.

Four NOAA ships—the MT MITCHELL, PEIRCE, WHITING, and FERREL—a plane, a hydrographic field party, and land support units will carry out the program in coastal waters extending from Cape Hatteras, N.C., to the vicinity of Cape Kennedy, Fla., and out to sea as much as 300 miles. The water depths being surveyed range from the surf zone area to 16,000 feet at sea.

The study of the southeastern coast of the United States, dubbed Project SCOPE for Southern Coastal Plains Expedition, is designed to compress within two years projects which had previously been programmed for the next 12 to 15 years. Similar concentrated studies are being planned for other east coast areas after the present survey is completed.

The study is a scientific and fact-finding program which combines the resources of NOAA and academic, regional, and state agencies in solving environmental problems in the coastal zone. The expedition is designed to provide coastal zone planners with data which will enable them to predict the consequences of both nature's and man's activities in these areas. Complete processing of the data will be accomplished in about a year, following completion of the field work, some of it while field work is still under way.

Among important aspects of the study will be obtaining data enabling planners to cope better with coastal water pollution and to determine state and federal seaward boundaries. From aerial photography of the coastline, photos will be available to coastal zone managers preparing base maps for delineating coastal zone activities. In southern Georgia, new aerial photography will be used to delineate the mean low water line (the federal boundary) and the mean high water line (the state boundary). Recent photography will be used in all other shore areas.

SCOPE will involve, in addition to aerial photography of the coastline, surveys of the sea bottom's topography, charting of coastal waters, tidal current and tidal surveys, and studies of the sea's physical properties, such as salt content and temperature of the water, and delineation of the Gulf Stream.

The field work will terminate in mid-December 1974.

FISH DATA AVAILABLE BY PHONE

New 24-hour-a-day message centers that will provide daily information of fresh fish landings and ex-vessel prices have been placed into operation at National Marine Fisheries Service Offices in Gloucester and New Bedford, Mass.

Russell T. Norris, Northeast Regional Director of the NMFS, said the new message centers will provide accurate and dependable information from the Statistics and Market News Division for the general public.

According to Mr. Norris, both offices receive daily many calls for arrivals, landings and prices, and the new service will answer many callers' routine questions by providing information more effectively and accurately. It is not intended to replace regular service if more detailed data or other types of fishery information are needed.

The new message centers are expected to reduce operating expenses and the 24-hour-a-day announcing system will improve services to the public.

Telephone numbers for the new 24-hour announcing service are Gloucester, Mass. (617) 283-1101 and New Bedford, Mass. (617) 993-5000.

Kresge, Nordenson Appointed to NWS Hydrology Posts

Kresge

Nordenson

Ralph F. Kresge has been named Deputy Director of the National Weather Service's Office of Hydrology, a new position created in the recent reorganization of the Office of Hydrology.

Since 1967, Mr. Kresge has served as Assistant to the Weather Service's Associate Director for Hydrology. He began his Weather Service career in 1946 at Chicago, Ill., and served subsequently at the St. Louis River Forecast Center before going to Washington, D.C., in 1950 as staff hydrologist.

He holds a B.S. in earth science (meteorology) from Pennsylvania State University, and did graduate work at Stanford University in 1959-60 under a Weather Service scholarship.

Tor J. Nordenson has been appointed Director of the National Weather Service's Hydrologic Research Laboratory. He had been Acting Director of the Laboratory since March 1972.

Mr. Nordenson joined the NWS in 1946 in the Procedure Development Section (predecessor of the Hydrologic Research Laboratory) in the Office of the Hydrologic Director. He served in the U.S. Navy from 1943 to 1946, and prior to that was employed by the Tennessee Valley Authority. He received his B.S. in civil engineering from the University of Michigan in 1936.

NEIC Reports 10,000 Killed By '72 Quakes

Earthquake activity in 1972 was average in terms of tremors felt in the United States and worldwide energy release, but catastropic in terms of lives lost, although no earthquake-caused fatalities in the United States were reported during the year.

The National Earthquake Information Center based its preliminary assessment of 1972 seismic activity on data reported by nearly 600 cooperating stations around the world, and on its determinations of epicenters (surface positions), magnitudes, and other aspects of some 4,500 shocks during the year.

The NEIC reports that:

—Total earthquake-caused fatalities of "about 10,000" represent a nearly tenfold increase over the 1971 figure of 1,057. Two disasters made the difference: the April 10 earthquake in southern Iran that reportedly killed 5,374 persons, and the December 23 tragedy in Managua, Nicaragua, where uncounted losses are estimated to be between 4,000 and 6,000 lives.

—It received reports of 282 felt earthquakes in 22 states. The largest of these, a magnitude 7.6 shock on July 30 near Sitka, Alaska, caused remarkably little damage there (about $9,000) but was felt over a 50,000-square-mile area of Canada and southern Alaska.

—California again led the states in the number of felt earthquakes, with 117 reported. Alaska, the second-rated state in the number of felt earthquakes, reported 113; however, this lower figure is more the result of Alaska's low population density than its comparative seismic activity, which is higher than California's. Montana was third, with 19 felt earthquakes reported, followed by Utah, with 7, Hawaii, 4, and South Carolina, 3. Two felt earthquakes each were reported for Missouri, Arkansas, and Colorado, and one each for Arizona, Idaho, Illinois, Nebraska, Nevada, New York, Oregon, Pennsylvania, Texas, Virginia, Washington, West Virginia, and Wyoming.

—Six tsunamis—long period ocean waves sometimes generated by earthquakes in coastal or oceanic areas, erroneously called "tidal waves" when they reach destructive size—were reported in the Pacific Ocean area during the year. None of these caused significant damage.

NOAA Establishes Advisory Service To Aid Users of Marine Resources

A NOAA Marine Advisory Service, designed to put information on marine resource utilization directly into the hands of people who need it, has been established.

In announcing the new service, Dr. Robert M. White, NOAA Administrator, said, "The NOAA Marine Advisory Service will link the findings of scientists and engineers to all who seek livelihood or recreation from the sea. We are building upon the successful 60-year tradition of the agricultural extension service, linking colleges and universities to users at the grassroots level."

The Sea Grant Advisory programs that have already been established on every salt water coast and the Great Lakes will be part of the NOAA Marine Advisory Service. Howard H. Eckles, formerly NOAA's Assistant Associate Administrator for Marine Resources, has been appointed Acting Program Manager of the service, which is administered within the Office of Sea Grant.

NOAA staff from the major components who have been designated to serve as headquarters-level marine advisory personnel are: J. David Almand, National Marine Fisheries Service; Craig H. Hooper, Environmental Research Laboratories; Captain Roger Lanier, National Ocean Survey; Richard Morse, Environmental Data Service; Max W. Mull, National Weather Service; Dr. Daniel A. Panshin, Office of Sea Grant; and Dr. Robert L. Pyle, National Environmental Satellite Service.

NOAA technical staff from all components of NOAA may be called upon as experts, appearing at workshops, helping solve problems posed by users, and participating actively in local advisory projects.

The Marine Advisory Service will work cooperatively at the State level, and will not involve regional staffing. It is designed to be flexible, so that it can meet the particular local needs of communities, states and regions. In some areas, local marine advisory programs may become closely integrated with the already-existing agricultural extension services.

Present areas of emphasis which will be expanded and assisted by the national program are commercial and sports fishing, seafood processing and marketing, coastal zone management, marine recreation, and marine science education for the general public. Emerging areas of emphasis include aquaculture, marine mining, and maritime transportation and port development.

STERLING LAB HAS ELECTRIC VEHICLE

The first enclosed electric car obtained for use by a Federal agency has been delivered to the National Weather Service's Test and Evaluation Laboratory at the Sterling Research and Development Center, Va.

The car, obtained under special permission by the General Services Administration, is a two-seater to be used by T&EL personnel to transport themselves over the 400-acre tract.

Maryland Congressman Gilbert Gude (center above) was on hand for the delivery of the electric car (below).

NODC Publishes CICAR Volume

"CICAR, Volume III, Bibliography on Marine Geology and Geophysics" has been published by Environmental Data Service's National Oceanographic Data Center with funds provided by the National Science Foundation.

The publication is an assemblage of published knowledge on the CICAR (Cooperative Investigation of the Caribbean and Adjacent Regions) area. Part I includes an extensive compilation of published literature on the marine geology and geophysics of the Caribbean Sea, Gulf of Mexico, Greater and Lesser Antilles regions, and the adjacent areas of North, Central, and South America. All references appear chronologically and are alphabetized by author within each year. A subject matter index, an author index, and a geographic index make up most of Part II.

Preparation of the volume's contents was a cooperative effort of many countries, institutions, and individuals. Original manuscript material was organized, cataloged, and edited under contract by the Franklin Institute Research Laboratories.

NOAA Puts Musicians on the Map

At the bottom of the sea in the north central Pacific are seamounts named for some of the world's most illustrious musicians—Rachmaninoff, Tchaikovsky, Mozart, Chopin, Haydn, Liszt, Paganini, Handel, Grieg, Ravel, Gounod, Sibelius, Scarlatti, Schumann, Mendelssohn, Gluck, Prokofiev, and Khachaturian.

Submerged by one to three miles of water, they are part of a range of approximately 65 prominent seamounts and ridges that make up the Musicians Seamounts, a chain of undersea features which rise some 24,000 to 12,000 feet above the bottom, approximately 400 nautical miles north of Honolulu, Hawaii. Two of the ridges bear the names of Bach and Beethoven.

A map showing the topography of a portion of the Musicians Seamounts and the surrounding area—the most detailed of its kind to be published for this region—has been issued by NOAA. The bathymetric map is based generally on data gathered during a decade of ocean research, from 1961 to 1970, by Commerce Department vessels. It is one of eighteen geophysical maps, portraying bathymetry, magnetics, and gravity, being prepared that will cover an area of approximately one million square nautical miles of two regions between Hawaii and the Aleutians, extending north and south about 1,800 miles and east and west approximately 1,000 nautical miles.

The name for the chain had been suggested in 1964 by a Scripps Institution of Oceanography marine geologist, Henry W. Menard. Following detailed surveys of the area by the NOAA Ships PIONEER and SURVEYOR, two oceanographers of the Pacific Oceanographic Laboratories, Frederick P. Naugler and David Rea, assigned names to the 18 seamounts.

The map, which measures 3½ by 2¾ feet, is available for $2 from the NOS Distribution Division (C44), Riverdale, Md. 20840. It is part of the NOS Seamap Series of the North Pacific Ocean and bears the designation 15524-10B. Geophysical overlays will probably be available within the next two months, and will sell for $2 each. The magnetic overlay will bear the designation 15524-10M, and the gravity overlay will be identified as 15524-10G. In addition to the Musicians Seamounts Chain, the may also covers the western part of the Murray Fracture Zone.

all in the family

PERSONNEL NOTES

Commander James Collins is now Deputy Director of the National Geodetic Survey, the first to hold that position. He formerly was Commanding Officer of the RUDE and HECK.

Robert K. Crowell is the new executive officer of the National Marine Fisheries Service. In his most recent post as a management analyst with NOAA's Systems Development Project, headquartered at Rockville, he participated in the design and implementation of a uniform financial management system for NOAA.

Commander John D. Bossler has been named the Scientific Advisor to the Director of the National Geodetic Survey, the first to fill that position. He comes to the new position from Columbus, Ohio, where he received his Ph.D. in geodetic science from Ohio State University.

Dr. Richard F. Myers has been named Superintendent of the National Weather Service's Technical Training Center at Kansas City, Mo. He previously was an Associate Professor of Biology at the University of Missouri in Kansas City.

Lewis A. Pitt has been appointed to the Special Projects Staff of the Environmental Data Service to advise on observing and instrumental practices and on the network design of the National Weather Service. His last assignment was at the Weather Service's Lower Mississippi River Forecast Center in Slidell, La.

Captain Edwin K. McCaffrey, has been assigned to the staff of the Director of the Environmental Data Service. He was previously Commanding Officer of the MT MITCHELL.

Lieutenant Commander Leonard E. Pickens has been named Commanding Officer of NOAA's wire drag ships, the RUDE and HECK. He was executive officer of the ships for the past year.

Lieutenant Commander William M. Noble who last served as chief pilot for the National Ocean Survey's Coastal Mapping Division, is the ships' new Executive Officer.

Commander Ronald M. Buffington, who has been serving as special assistant to the Director of the NOAA Corps, has been appointed Commanding Officer of the NOAA Ship MT MITCHELL.

Commander Michael H. Fleming has been named Commanding Officer of the NOAA Ship DAVIDSON. He was formerly liaison officer at the State Department's Office of International Affairs.

Commander Lavon L. Posey has been named Commanding Officer of the NOAA Ship RESEARCHER. He has been the ship's Executive Officer since last June.

Dr. Neil L. Frank has been named Deputy Director of the National Weather Service's National Hurricane Center in Miami. Dr. Frank began his career in meteorology while serving as a weather officer in the Air Weather Service. He joins the National Weather Service in 1961.

Dr. James M. Hall has been appointed Chief Scientist of the National Ocean Survey's National Data Buoy Center at Bay St. Louis, Miss. Since 1970 he has been conducting oceanographic research for the Shell Development Company.

Herbert S. Groper, former Meteorologist in Charge of the National Weather Service Office at Trenton, N.J., in a new position with the Office of Hydrology at NWS Headquarters in Silver Spring, Md., is now responsible for planning and coordinating the national flash-flood program.

Cecil E. Simmons, who has been Principal Assistant at Charleston, W. Va., for the past two years, has been appointed Meteorologist in Charge at the Trenton, N.J., Weather Service Office.

Nile Woltman, former Principal Assistant at the Pendleton, Oreg., Weather Service Office, is now Meteorologist in Charge at the Eugene, Oreg., WSO.

Lieutenant Albert E. Theberge, Jr., is the new Chief of Astronomic Party G-47.

James W. Taylor is now Chief of the National Geodetic Survey's Geodetic Leveling Party G-36.

Dr. Ronnie L. Alberty has joined the Environmental Research Laboratories' National Severe Storms Laboratory in Norman, Okla., to be in charge of NSSL's storm modeling and forecasting project. He was formerly associated with the United States Naval Postgraduate School in Monterey, Calif.

Commander Walter L. Bradly is now the Executive Officer of the RAINIER. He was formerly Chief of the Processing Division at the Pacific Marine Center.

David C. Brown, Weather Service Specialist at the Weather Service Office in Pocatello, Idaho, has been selected Official in Charge of the Weather Service Office in Ely, Nev.

Lieutenant Commander James P. Brown, Jr., is the new Chief of the Requirements Section in the National Ocean Survey's Office of Marine Surveys and Maps in Rockville, Md. He was previously assigned to the Office of Ecology and Environmental Conservation.

Commander Donald J. Florwick has been appointed Executive Officer of the RESEARCHER. He recently completed a 30-month assignment in Miami, Fla., as Liaison Officer at the Atlantic Oceanographic and Meteorological Laboratories.

Robert C. Baskin, who has been Chief of the Operations Division of the National Weather Service Central Region is now Deputy Director of that region.

Lieutenant Clarence W. Tignor is the new Executive Officer of the NOAA Ship FERREL. He recently completed a three-year assignment with the National Ocean Survey's Coast Pilot Branch in Rockville, Md.

Commander Sigmund R. Petersen has been assigned to the GATE Project Office, Bracknell, England, after 18 months with the Lake Survey Center, where he was Operations Officer and, for a time, Acting Director.

Daniel J. Riedy, Supervising Meteorological Technician at the Los Angeles, Calif., Weather Service Forecast Office, has been selected for the position of Official in Charge at the Weather Service Office in Pocatello, Idaho.

Gerald L. Robinson has been appointed Meteorologist in Charge of the Weather Service Office in Palmdale, Calif. He was formerly a Weather Radar Specialist at the Auburn, Wash., Weather Service Office (Radar).

Lieutenant Commander Fidel T. Smith is the new chief of Hydrographic Field Party 746.

Jack R. Routh, who has been Chief of Personnel in the National Weather Service Alaska Region since 1971, has been selected as the Chief of the Central Region's Personnel Division.

Commander Raymond L. Speer, who formerly was the Executive Officer of the NOAA Ship RAINIER, is the new Operations Chief at the Pacific Marine Center in Seattle, Wash.

Wesley O. Means has been named Chief of the National Geodetic Survey's Geodetic Field Party G-34.

Lieutenant Gregory L. Miller is the new chief of the National Ocean Survey's Gravity Party G-52.

Lieutenant Commander Donald E. Northrup is the new Executive Officer of the McARTHUR. He recently served on the FAIRWEATHER.

Commander Freddie L. Jeffries is the new Executive Officer of the NOAA Ship FAIRWEATHER. He held a similar post on the NOAA Ship McARTHUR.

Commander K. William Jeffers has become Executive Officer of the NOAA Ship OCEANOGRAPHER. He was previously Chief of the Operations Division at the Pacific Marine Center.

Captain Steven L. Hollis has been assigned to the Office of the Oceanographer of the Navy, where, as Liaison Officer, he will help coordinate related activities of the Navy and NOAA. He recently served as Commanding Officer of the NOAA Ship RESEARCHER.

Cold Water Eddies Affect Weather, NOAA-2 Data Shows

A link between cold water eddies and the weather has been reported by NOAA amid reports that more of the swirling masses of water have been detected moving down the Atlantic coast.

Cold water eddies are calm bodies of water, generally circular in form, which revolve counterclockwise off the Atlantic coast, traveling southwestward at a speed of one to two miles a day.

Since the first cold water eddy to be tracked was initially observed by the Navy in October 1970, oceanographers, including those at NOAA, have been attempting to determine what effect, if any, the gigantic eddies have on east coast weather after they are formed by breaking through the warmer Gulf Stream.

Dr. Alan E. Strong, an oceanographer at the National Environmental Satellite Service, said it has now been determined, from observations made by NOAA-2, that cold water eddies affect some low-lying clouds over the ocean.

"The cold water eddy observed by the satellite apparently dissipated trade wind cumulus clouds a few thousand feet above the surface," he said. "The 1½ to 2 degrees' difference in surface temperature in the cold water eddy compared with the water surrounding it is apparently sufficient at times to dissipate low-lying clouds."

Poster Features California Fishes

The National Marine Fisheries Service has published a poster displaying 51 marine fishes of the California Current and adjacent waters. Third in a series of fish posters depicting aquatic inhabitants of U.S. waters, the poster portrays sport and commercial species caught in California coastal waters from Monterey south to Mexico, set against natural habitats.

Thousands of copies of the first two charts, one devoted to fishes of the North Atlantic, and the second to fishes of the North Pacific, have been distributed to fishermen, students, educators, and art collectors over the past year.

The fourth poster, to be issued later this year, will show fishes of the South Atlantic Ocean and the Gulf of Mexico. Subsequent subjects will be fishes of Hawaii and the Central Pacific, and shellfish.

Developed by Bob E. Finley, chief of the NMFS National Marketing Services Office, the 30-inch-wide by 48-inch-long, four-color charts are printed on washable non-glare plasticized paper that hangs flat against a surface without curling. A list of common and scientific names of the fishes is included, as well as artwork that shows seafloor life common to the mid- and southern-California seafloor. Copies may be ordered from Government bookstores and the Superintendent of Documents, Washington, D.C. 20402, for $2.25.

ERL Studies Doppler Technique For Identifying Birds in Flight

Environmental Research Laboratories' scientists are developing a doppler radar technique for identifying birds in flight. Once perfected, the technique may be applied to airport safety in areas where birds are a hazard. It also may help solve the mysteries of bird migration and other ornithological questions.

For several years, NOAA has employed doppler radar to investigate tornadoes, monitor motions of the ionosphere, and chart the life histories of thunderstorms. Now, Dr. Ben B. Balsley and John L. Green of the Aeronomy Laboratory believe that doppler radar is adaptable to identification of birds by flight characteristics.

Conventional radar techniques are currently used by some ornithologists to map bird migrations. This method involves tracking the bird's movement over the ground. Doppler radar, on the other hand, gives a continuous measurement of the bird's radial velocity—the speed at which the bird is moving towards or away from the radar antenna.

Focusing doppler radar on a bird, Dr. Balsley and Mr. Green simultaneously measure the radial-velocity contributions of the various parts of the bird's wings and body. This information is then plotted graphically, as a "special signature," typically showing a heavy line for the body intersected perpendicularly and periodically by thinner lines representing wing beats. Preliminary results indicate that different bird types yield distinct spectral signatures.

The scientists hope their research will ideally produce a set of species-specific signatures that will enable ornithologists to establish a catalog of doppler radar bird identifications.

The U.S. Air Force, which loses several pilot lives and millions of dollars' worth of jet engine parts annually due to bird collisions, is funding the one-year NOAA study to determine the feasibility of doppler radar bird species identification.

Collaborating with the NOAA researchers is Professor Warren Flock of the University of Colorado, who has performed conventional radar bird-identification studies for the U.S. Air Force since 1968.

Ice Forecast Services Increased To Aid Lake Navigation Project

The National Weather Service, in cooperation with the U.S. Coast Guard, has expanded its ice-forecasting service for commercial shipping on the Great Lakes.

The effort is part of the Demonstration Program to Extend the Shipping Season on the Great Lakes and St. Lawrence Seaway, under the general management of the Army Corps of Engineers. NOAA and a number of other agencies, both public and private, are participating in the program—now in its second year—aimed at lengthening the navigation season on the Great Lakes during the winter months.

Traditionally, ice has blocked passage of ore boats and other large vessels on the lakes for periods of two to three months each winter. Officials believe faster and more-detailed weather reports will help commercial skippers keep going longer.

As one part of the ice-forecasting expansion, the NWS this year assigned a meteorologist to the Coast Guard Ice Navigation Center at Cleveland. His work will supplement that of the main Great Lakes Ice Forecasting Center at the National Weather Service Forecast Office in Detroit.

The Cleveland center is equipped with regular Weather Service teletypewriters and facsimile equipment so that personnel there have available the latest weather observations and forecasts for briefings and chart information to relay to shipping agents and vessel captains.

The main ice-forecasting unit at the weather office in Detroit has expanded its service to issue ice and weather reports twice a day, instead of once a day—an ice outlook issued at 10:40 a.m. will give mariners general information extending over the next several days; and an ice forecast will provide more specific information for a period ending at 7 p.m. the following day. Both will be available from Coast Guard radio stations.

Early in January, a new marine teletypewriter network for the Great Lakes became operational, linking U.S. and Canadian weather stations and commercial marine radio stations. Information on this circuit includes routine ice and weather forecasts, storm watches and warnings, observations from ships and shore stations, notices to mariners, and urgent Coast Guard messages pertaining to navigation on the lakes. Non-Government agencies desiring this teletypewriter service may obtain information on installation and cost of necessary equipment from the ice forecaster at Cleveland.

To facilitate coordination of marine warnings, a dedicated telephone system has been installed linking the four principal weather forecast offices on the Great Lakes, including the Toronto office, and the Coast Guard's Ice Navigation Center in Cleveland, Calls on this system will be restricted to Great Lakes weather-and-ice problems.

Nimbus-5 Sounder Developed by NESS

The National Aeronautics and Space Administration's experimental satellite Nimbus-5, launched late December 10 (Pacific Standard Time), carries an infrared temperature profile radiometer developed under the direction of W. L. Smith and D. W. Wark of the National Environmental Satellite Service. Designed to sound atmospheric temperatures to cloud tops or the ground, the ITPR is similar to the vertical temperature profile radiometer on NOAA-2, but has a smaller field of view and higher resolution.

Other experiments on Nimbus-5 are an electrically scanning microwave radiometer and the Nimbus-E microwave spectrometer which will penetrate thin clouds and stratus to measure temperatures in the atmosphere and at the earth's surface; the selective chopper radiometer, a British experiment to observe the global temperature structure of the atmosphere from cloud tops to an altitude of 31 miles; the temperature humidity infrared radiometer which provides cloud pictures and water vapor data; and the surface composition mapping radiometer which measures differences in the thermal emission characteristics of the earth's surface.

One of the principal objectives of the Nimbus-5 mission is to provide data and develop advanced sensors needed for the Global Atmospheric Research Program and the World Weather Watch.

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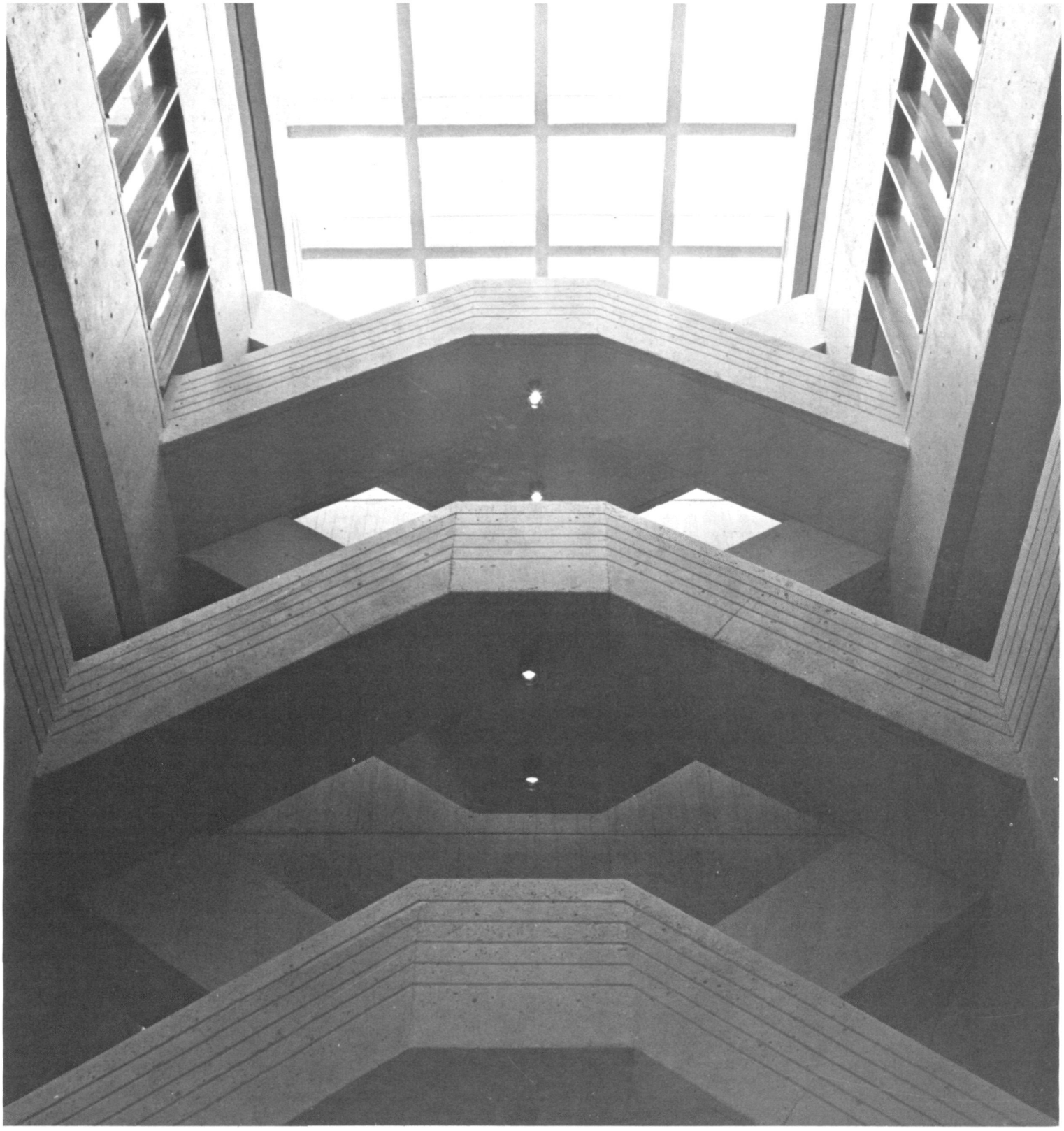
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