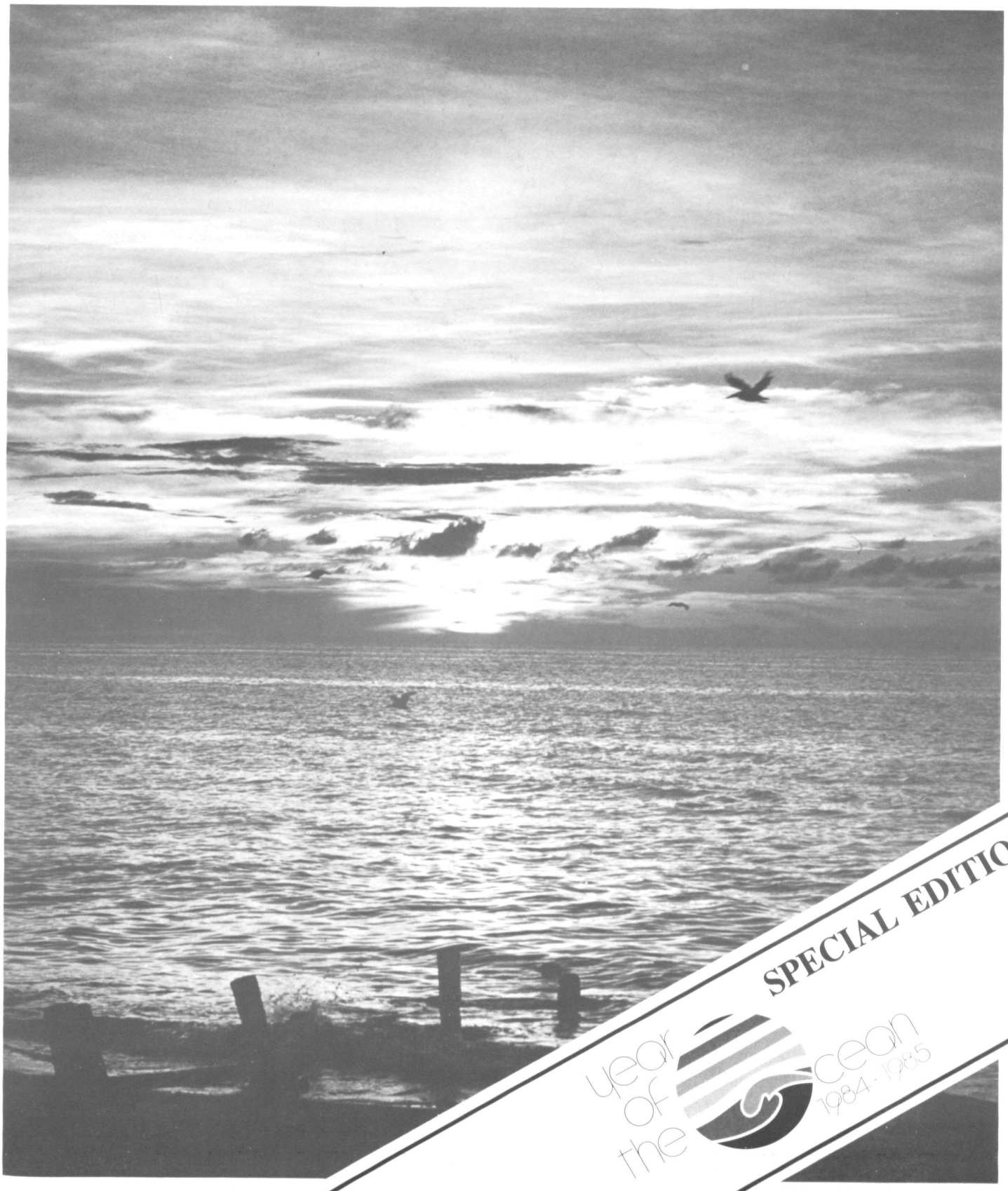
Volume 14 Number 2 Summer 1984

noaa



SPECIAL EDITION

year of the ocean 1984-1985

National Oceanic and Atmospheric Administration

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Volume 14

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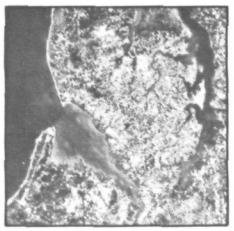
noaa



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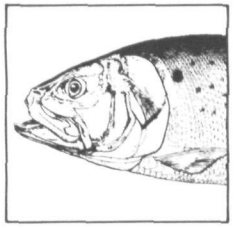

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NOAA (USPS 417-370) is published biannually by the Office of Public Affairs, National Oceanic and Atmospheric Administration, Washington, D.C. 20230, to acquaint readers with the policies and programs of the agency. The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget.

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Newsline

NOAA, USGS To Map the EEZ

The United States, which nearly doubled its size with President Reagan's 1983 proclamation of the Exclusive Economic Zone 200 miles out from its shores, will map the largely uncharted six million square-mile area—a project unmatched in ocean mapping history, in an area that totals nearly twice the United States' land size. NOAA's National Ocean Service and the U.S. Geological Survey have launched a cooperative multi-year program to provide the basic "roadmaps" vital to systematic resource exploration, development and conservation of the zone. In early phases of the project, NOAA specialists will conduct marine mammal observations, analyze pollutant chemicals in conjunction with EPA, and take weather and oceanographic observations along with seafloor mapping. The project will begin in the Pacific, with the West Coast scheduled for 1984-85, Alaska in 1986, the Hawaiian Islands in 1987, and the Trust Territories to follow. East and Gulf Coast schedules have not yet been set.

Members of NOAA Family Honored

Named Employees of the Year are A. Venus Peters, staff and personnel employee relations specialist; Chris Fee, personnel management specialist; and Barbara Naecker, program assistant, all of Administrative and Technical Services; and Bonnie Sue Maynard, staff assistant in the National Ocean Service. The Association of NOAA Commissioned Officers has chosen Lt. Lawrence Simoneaux as Junior Officer of the Year and Cmdr. Kenneth Lilly as recipient of its Science Award. Lt. Cmdr. Gerald B. Mills, executive officer of the Fairweather, received the American Society of Military Engineers' Colbert Medal.

ERL Spots Arctic Cyclones

NOAA research has documented for the first time the existence of arctic cyclones, fast-moving storms with hurricane-force winds and 50-foot waves. A six-week airborne study over the Norwegian Sea by the Environmental Research Laboratories established that the rotating motion of the storms can create circular surface winds strong enough to threaten oil rigs and capsize small vessels, and cause dangerous superstructure icing on ships. Extensive data on storm structure and behavior, and sea state conditions, were gained on flights from Iceland and Norway, at altitudes ranging from 1,000 to 25,000 feet. It's expected to lead to better understanding and forecasting of storm development and movement from the Arctic Circle to populated areas.

NMFS Slashes Inspection Fees

National Marine Fisheries Service has sharply reduced the hourly rate it charges some 500 fish processors and others to inspect their products. The reduction was achieved by charging for only direct costs, and absorbing related costs in other areas of the NMFS program, to encourage fish enterprises, particularly smaller firms, to participate. The cut will average about 18 percent, saving users almost $600,000. Last year users paid about $3.7 million for the voluntary inspection service. The program, begun in 1958, offers impartial inspection of all processed fishery products, and increases consumer confidence in the products that bear the Department of Commerce inspection mark or the government grade shield.

Wolff Named Assistant Administrator

Paul M. Wolff, senior scientific advisor to Ocean Data Systems, Rockville, Md., and president of its subsidiary Global Weather Dynamics, Inc., has been named Assistant Administrator for Ocean Services and Coastal Zone Management. Widely known for his work in oceanographic and marine weather analysis and prediction, he founded the U.S. Navy Fleet Numerical Weather Central in 1959 and commanded it until 1970. Wolff has designed marine weather service for Saudi Arabia and Iran, created a computer weather service for 15 nations, and has undertaken extensive ocean investigation to determine areas where thermal structure is favorable for ocean thermal energy conversion plants.

Yost Business Office Director

Norma E. Yost has been named director of the newly-created Office of Business Affairs. The office works with major corporations, large companies, trade associations, and other business organizations to assure that their concerns are considered in NOAA's policy decisions. Ms. Yost joined the Department of Commerce in 1982, serving in the International Trade Administration and, most recently, as Deputy Director of the Office of Business Liaison.

New Undersea Unit for NOAA

A Northeast-Great Lakes unit will be added to NOAA's undersea research program in August. The National Undersea Research program's first cold-water activity will begin in the Gulf of Maine, surveying ocean dumping grounds and studying the productivity of the area's high-value fish. The ocean dumping survey will make detailed maps of dumpsites off Portland and Boston, and assess the effect of the dumping on marine life. Productivity studies will focus on factors affecting productivity of lobster, shrimp, crab, sea scallops, haddock, cod, hake, and redfish.

Panshin To Direct Extension

Dan Panshin, former assistant administrator of the Agriculture Department's Extension Service, will direct a new extension program office. Panshin has held posts as program director of advisory services with NOAA's Office of Sea Grant and as assistant director and extension oceanographer with the Sea Grant Program at Oregon State University before joining the Department of Agriculture in 1981. He has also served as congressional fellow in the Office of Technology Assessment and staff director of the House Subcommittee on Maritime Education and Training.

40-Year Employees Congratulated

Congratulations on 40 years of dedicated service to the Federal government have been extended by Administrator John V. Byrne to David Q. Wark, Roderick Quiroz, William I. Pogerman, Dorothy McNamara, Chester P. Jelesnianski, and James I. Elliott of the National Weather Service; and to Victor J. Mosesso, John L. Berger, and George W. Reid of the National Ocean Service.

An Estuary On The Mend

by Roland D. Paine

The Delaware River rises in southern New York state, about 1,885 feet above sea level, and winds generally southward, out of the Catskills and down through the Delaware Water Gap. It becomes Pennsylvania's eastern border, first with New York, then with New Jersey.

Ultimately the handsome stream reaches Trenton, where industrial and urban build-up begins to be felt. On its way to the sea it picks up municipal wastes from nearly 5 percent of the U.S. population—up to 500,000 pounds of sewage and treated industrial waste daily, agricultural runoff, tons of sediment from erosion and from land development.

Flowing past Philadelphia it picks up about 10 percent more water from its major tributary, the Schuylkill River, and gradually widens into the great shallow estuary of Delaware Bay, separating New Jersey on the east from Delaware on the west. Here it becomes a broad, sluggish inlet of the sea, bordered by marshes, channeled by the U.S. Government, charted by NOAA's National Ocean Service. Traversed by ships from throughout the world, it supports one of the Nation's highest concentrations of commercial shipping. It finally reaches the mouth, where salt water enters between Cape May and Cape Henlopen, about 116 nautical miles from Trenton.

A Landsat photograph of Delaware (upper right) and Chesapeake Bays, showing turbidity of the relatively shallow Delaware. Cape May, N.J., stretches down toward Cape Henlopen, Del., at the Bay's mouth.

Delaware Bay is one of the four or five largest estuaries in the United States. Thirty years ago its upper reaches were also among the most badly polluted. Today, after massive Federal, state and local cleanup efforts over the intervening decades, it is in better health, its water quality greatly improved.

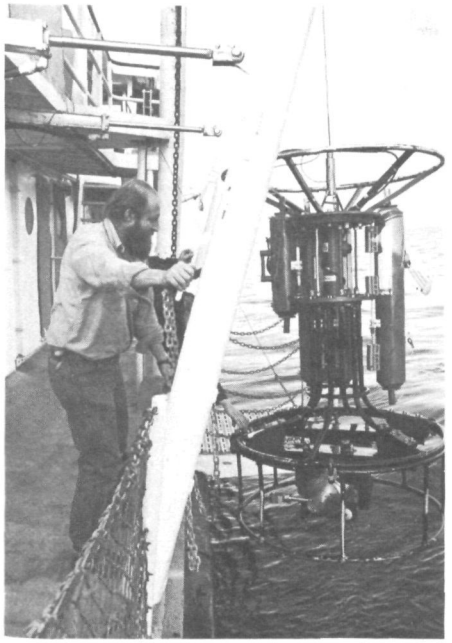
A 3-year joint study by the Delaware and New Jersey Sea Grant programs has confirmed the cleanup as relatively successful, but warns that the estuary is feeling continued pressure from human activities, and needs to be managed carefully and understood in greater detail.

Funded by NOAA's National Sea Grant College Program, and with additional support from the Delaware River and Bay Authority, the study has had as its major purpose finding out just how the Delaware estuary works. Its findings—and those of ongoing research, including a circulation survey now under way by the National Ocean Service—provide valuable information for officials of the two states and the Delaware River Basin Commission in their jobs of managing the estuary's resources.

The scientists found that the growth of phytoplankton in the bay is similar to that of productive estuaries elsewhere in the world. About 90 percent of the phytoplankton is produced in the broad, saltier lower reaches of the Bay where it supports fisheries that exist at much lower levels than in the past.

As is the case with its neighbor the Chesapeake Bay, the total commercial catch of fish and shellfish in the Delaware has declined substantially over the past few decades. There are signs that careful management is enabling the oyster fishery to begin to recover from the devastating effects of the MSX disease. The annual oyster yield dropped from 2 million bushels annually to almost zero in the late 1950's; current production is about 200,000 bushels.

Shad also appear to have increased in recent years. Other important bay fish include weakfish (often retailed as sea trout), blue fish, and flounder.



On RV Cape Henlopen, Timothy Pfeiffer of the University of Delaware (left) brings salinity-temperature-depth sampler aboard while Dr. Charles Culberson (bottom right) analyzes water samples. Michael Kubik (bottom left) of Lehigh University hauls benthic platform aboard RV Wolverine. (Photos: T. Church and C. Dyckman)

"We don't know why the fisheries have declined so markedly," said Dr. Jonathan H. Sharp of the University of Delaware, manager of the study, "because we don't know enough about natural cycles in fish populations and about the bay's food chains." Planned research will attempt to remedy this knowledge gap.

Because the bay is relatively shallow and flushes itself in about 100 days—three to four times faster than Chesapeake Bay, for example—dissolved oxygen concentrations, a measure of the water's health, are normal everywhere except near Philadelphia.

The outflow of contaminants from Philadelphia and other urban areas many years ago was the major cause of severe pollution of the Delaware. The first major cleanup began in the late 1930's, but was halted by World War II, during which the height of the environmental degradation was probably reached. But while the river was badly polluted then and in the decade of the 1950's, the bay continued to serve as a major and thriving sport and commercial fishing ground.

Major cleanup efforts were made on the river in the 1950's and again—under the aegis of the Delaware River Basin Commission and with the support of the Environmental Protection Agency—in the 1960's, continuing to the present time. The major concern, and the major gauge of cleanup, was dissolved oxygen concentrations.

Improved sewage treatment plants and more stringent effluent standards in the urban Philadelphia area have resulted in a marked increase in dissolved oxygen levels in the upper estuary.

"While the Delaware can hardly be considered pristine," Dr. Sharp said, "the improved water quality is very important. This is especially noteworthy because in many other estuaries, such as Chesapeake Bay, water quality is declining."

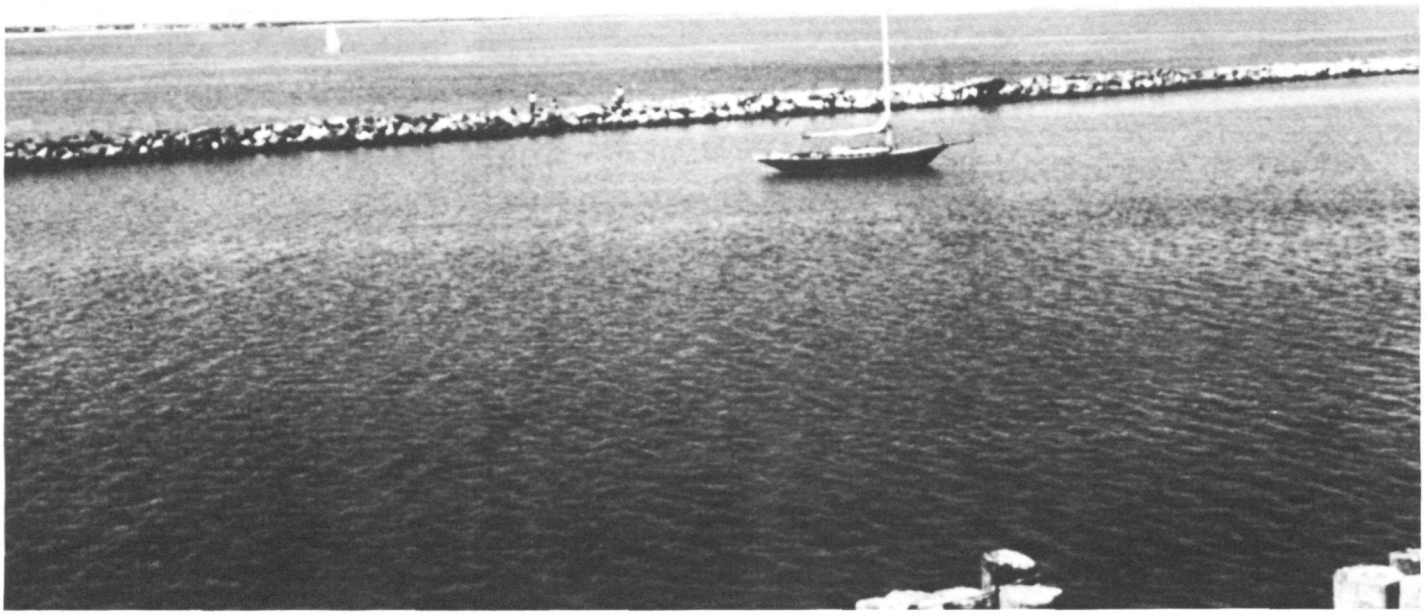
Interestingly, the improvement of water quality in the upper Delaware estuary does not appear to have affected fisheries populations in the bay, although there is some evidence that river fishery populations have increased.

The tides are the driving forces behind water circulation in the estuary, but river flow controls overall salinity. The flood tide moves water upstream for roughly 6 hours, then the ebb tide reverses the flow for another 6 hours. Salt water can intrude into the estuary almost as far upriver as Philadelphia, 80 nautical miles from the mouth. Typically, heavy spring river flows decrease the salinity, while periods of persistent drought permit salt much further up into the river.

Long-term changes in sea level are also affecting the salt content of the water. The overall sea level rise in this area has been about 6 inches since 1930, which, combined with increased upstream withdrawals of fresh water, had resulted in greater salt water intrusion into the bay and river. The increase in salinity forced the city of Chester, Pa., to abandon its local water supply in 1951, and find a safer source.

Water authorities can now exercise some control over water inflow into the Delaware by regulating water levels in reservoirs upstream.

The amount of nitrogen and phosphorus nutrients, when high, can cause a large increase in the growth of phytoplankton. This is a common phenomenon, and common danger, in many estuaries—too many nutrients cause massive algae blooms whose death and decomposition absorb the available oxygen and make the water uninhabitable for much desirable marine life. The mobile animals such as fish go elsewhere; the relatively immobile oysters and clams die.



A peaceful moment on Delaware Bay, where relatively few sailboats venture because of the shallow waters.

But it doesn't work that way in the Delaware, in spite of some of the highest estuarine nitrogen concentrations in the United States. Project scientists attribute this to two factors—the heavy concentration of suspended sediments in the water, which limit the light needed by the algae for reproduction, and the high rate of water flow that flushes the nutrients out of the upper estuary.

So, paradoxically, not all the human waste materials that go into the bay are harmful—some, by providing conditions for stable biological growth, may be helpful.

The estuary is healthy enough to support present levels of human pressure, and probably can support increased recreational and other uses, the scientists say—but they recommend that the states of Delaware and New Jersey manage the resource carefully, and continuously monitor its health.

The project consisted of both a scientific and a management study of the bay, and evaluates the roles of Federal, regional, and state managers.

Among the management functions discussed are those of fisheries, environmental protection, ports and marine terminals, and general planning and development.

The study was conducted by 36 researchers from Rutgers, Princeton, Lehigh, and Delaware universities, and the Stevens Institute of Technology. It is continuing, with Sea Grant support, to examine the relationships among the Bay's biological, chemical, physical, and geological systems with an ultimate goal of providing managers with a good understanding of how the estuary works.

Also contributing to the new knowledge about the estuary is a 15-month circulation project being conducted by the National Ocean Service, using the NOAA ship Ferrel. It is the first major circulation survey of the river and bay; limited information was provided by National Ocean Service current meter data collected in 1947 and 1953.

In addition to their uses for navigation, the new circulation data sets will provide valuable information to Federal and state managers of the system and its resources, and to university research groups such as the Sea Grant project. Measurements are being made of currents, tides, water conductivity and temperature, winds, air temperature, and barometric pressure.

The NOS survey was designed with the needs of the Delaware Estuary Project in mind, and scientists from the project serve on the informal working group of the NOS survey. Its data will help academic researchers develop numerical circulation models of the estuary, correlate the information with biological and chemical studies, and model sediment transport and oil spill trajectories.

Concurrently, the NOAA ship Whiting is making a hydrographic survey of the bay.

"The NOAA studies are a perfect complement to our own," Dr. Sharp said, "and we're looking forward with great anticipation to getting the data they'll produce. The Delaware estuary is a national asset—we're all very interested in it—and we're encouraged by the progress so far both in restoring its health and understanding its problems.

"The more we find out about how the estuary works," he said, "the more wisely we'll be able to use it." ■

NODC

Taking the Oceans' Measure

Don Bishop

At NOAA's National Oceanographic Data Center (NODC), every year is the year of the ocean. The ocean is what the center is all about—its reason for being.

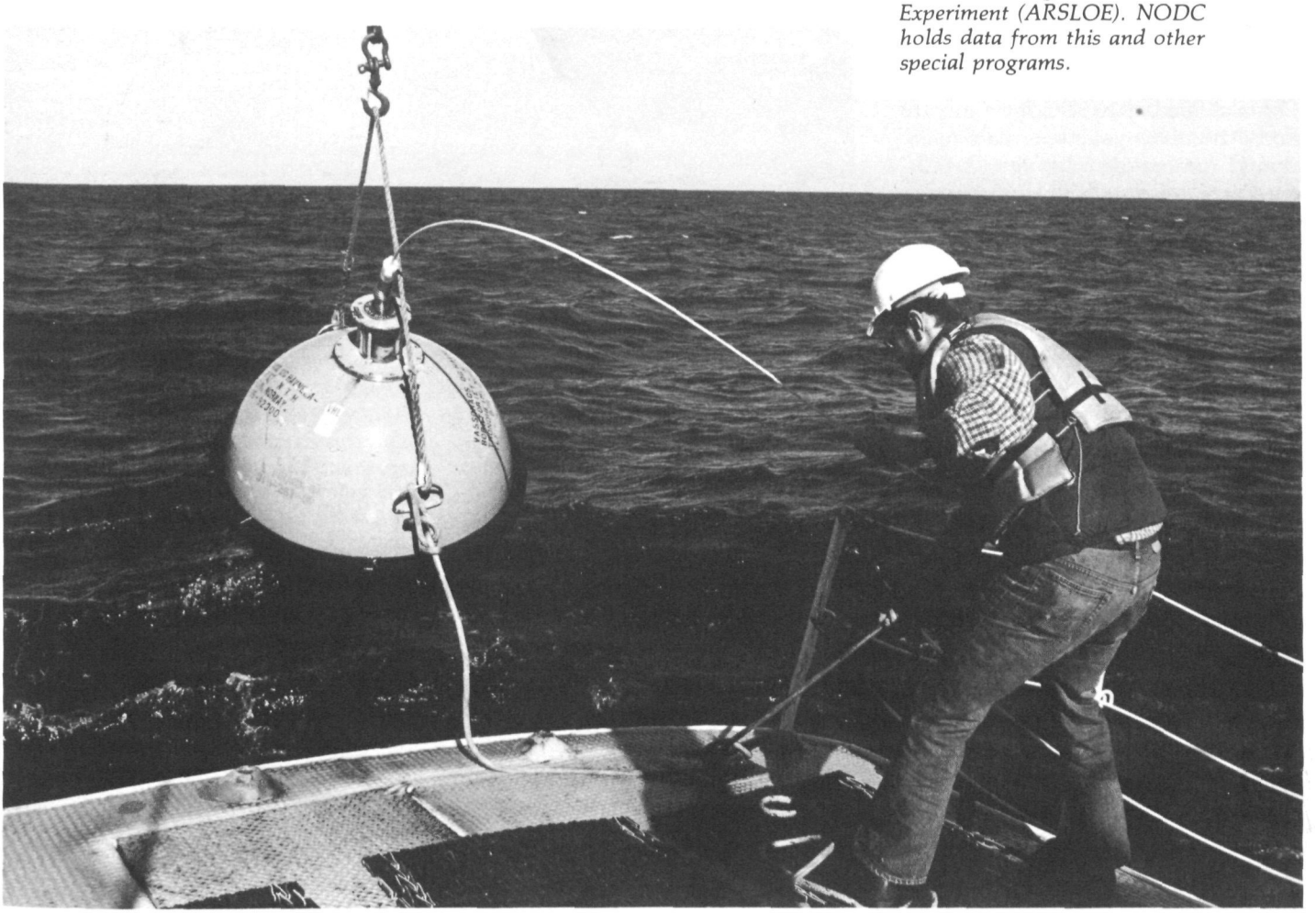
NODC collects, stores, and services users with data about the oceans which cover 71 percent of the Earth's surface. It's a formidable task: Where to begin? How much to do? How much *not* to do?

The center's charter grows out of a larger one given NOAA when it was established in 1970. NOAA was mandated to:

"Acquire and disseminate global environmental data and information tailored to meet the needs of users in commerce, industry, agriculture, the scientific and engineering community, the general public, and Federal, State, and local governments."

The basic idea for a facility like NODC is at least 30 years old. In 1954, at the second annual meeting of the Eastern Pacific Oceanic Conference (EPOC), Dr. O.E. Sette of the Bureau of Commercial Fisheries (now the National Marine Fisheries Service in NOAA) proposed the establishment of a central facility that would acquire, process, store, and disseminate global oceanographic data. Six years of studies, recommendations and legislative proposals went into creating the National Oceanographic Data Center as the United States' national facility to serve these functions. Speeding the process was the enormous growth in ocean and other geophysical research following the International Geophysical Year (IGY) of 1957-58.

A waverider buoy being deployed during the Atlantic Remote Sensing Land-Ocean Experiment (ARSLOE). NODC holds data from this and other special programs.



NODC was formally dedicated on January 16, 1961. Its six original sponsoring agencies (Navy, Coast and Geodetic Survey, Bureau of Commercial Fisheries, Weather Bureau, Atomic Energy Commission, and National Science Foundation) were later joined by four others (Coast Guard; Geological Survey; Health, Education, and Welfare; and the Army Coastal Engineering Research Center). The center was administered by the U.S. Naval Hydrographic (now Oceanographic) Office and remained under the Navy—housed at the old "Gun Factory," the former U.S. Naval Weapons Plant at the Washington Navy Yard—until the move to NOAA.

Since it was established—as the world's first national oceanographic data center—NODC has supported international cooperation in the marine sciences and benefitted from international oceanographic data exchange. It has served as a model for similar centers in other countries. Recently, for example, under the terms of a bilateral agreement between NOAA and the National Bureau of Oceanography of the People's Republic of China, NODC has aided development of an oceanographic data center in China. Three trainees from the Institute of Marine Scientific and Technological Information in the People's Republic of China studied at NODC for 6 months in 1982-83. Part of their training included processing through NODC systems of oceanographic data that they brought to the center from their home institution.

A development of far-reaching importance took place in 1962 when the World Data Center A for Oceanography was collocated with and placed under the management of NODC. Data centers in this and other scientific fields are located in many parts of the world for the international free exchange of non-classified data. NODC has estimated that, between 1969 and 1980, it received foreign oceanographic station data having a replacement value—if collected today at present ship operating costs—of over one billion dollars. World Data Center B for Oceanography is in Moscow, USSR.

NODC's bank of information primarily from the water column includes:

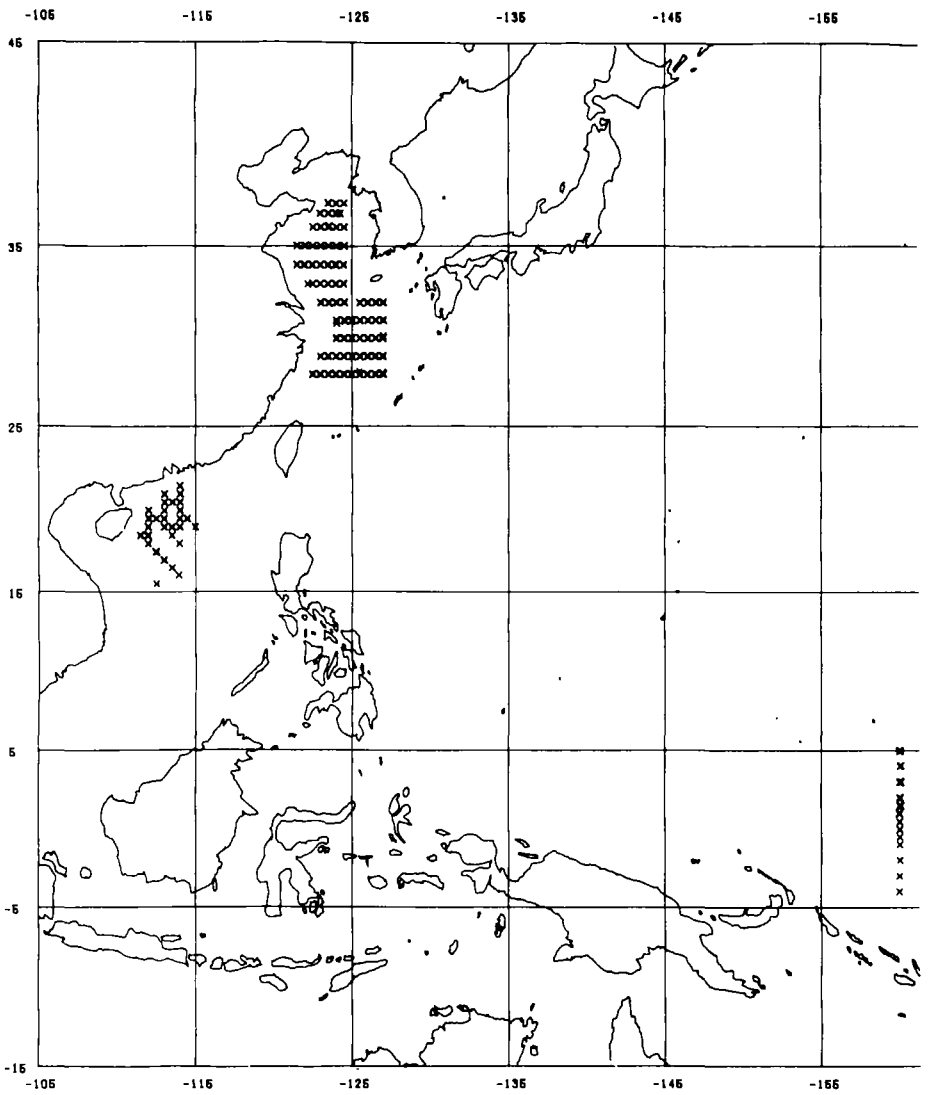
- "Classic" measurements of temperature, salinity, oxygen, and nutrient chemistry (for example, nitrate, nitrite, silicate, and phosphate).
- Additional chemical measurements of petroleum hydrocarbons, metals, pesticides, radionuclides, etc.
- Surface current measurements.
- Current meter measurements at depth.
- Observations for some areas of the occurrence and quantity of marine organisms including invertebrates, fishes, and mammals.

Patricia Kirk (top) of the User Services Branch searches NODC's data banks for requested data. NODC Director Edward Ridley (bottom) headed the U.S. delegation to a recent International Oceanographic Data Exchange meeting.

Looking back at the center's history in late 1983, NODC Director Edward L. Ridley recalled that the primary task of NODC's early years was to get organized and develop an operational marine data base.

"NODC's initial data collection," he added, "consisted of 2 million punched cards of physical/chemical data from Nansen casts (mostly from the North Atlantic); 3 million surface current (ship drift) observations; and 100,000 analog bathythermograph (BT) traces. Happily, the dark ages of punched cards and glass BT slides are now long since past; even by 1966 NODC's oceanographic station data file was almost completely converted to magnetic tape."

By the time it joined NOAA in 1970, the agency had increased by several-fold the volume of its original data holdings, Ridley said.



Locations of oceanographic stations in the first data submissions from the Peoples Republic of China under terms of an agreement between NOAA and the PRC National Bureau of Oceanography.

"Its digital files of oceanographic station data and bathythermograph data now totalled over 400,000 stations and 580,000 observations respectively. NODC also now had developed the capability to selectively retrieve data from these files and provide output as printouts, on magnetic tape, or in the form of an increasing variety of computer-generated data summaries, analyses, and graphic products."

NODC reached (and continues to reach) everywhere for data. It has no ships of its own, but it has many sources: NOAA's National Ocean Service, other governmental agencies, public and private oceanographic organizations, foreign entities, government grantees and contractors, etc. Liaison officers in five locations around the nation play an important role in gathering data (and later in disseminating it).

At times it may seem that, though computers can take frequent and voluminous feedings, a point comes when they are all but surfeited. Since NODC is constantly receiving both requested and unsolicited data, how does it meet its data acquisition mission without grinding to a halt under sheer volume?

"That's the million dollar question at the data center right now," said Peter Topoly, chief of NODC's Systems Planning and Integration Office. "The question probably takes up 80 percent of the data administrator's time; that is 'What kind of data does the NODC want?' And, 'What can we do with it when we get it?' Back in the old days if it was wet and it was salty, we took it. Because the automatic data processing environment has increased so tremendously, we are now getting geometric advances in the amount of data—actual data points that are being collected, processed and hopefully sent to the various national repositories. I can tell you that right now we do not have the additional wherewithal, the systems wherewithal, to handle all of the potential data that is out there. It is one of the major efforts that our data administrator and our data base administrators have to tackle, and that is, where do we draw the line?"

Related to this question is another: how to dispose of information for which there is no apparent need. First, NODC looks elsewhere in NOAA to ascertain whether another data center or one of the line agencies might wish to have the data. Beyond that the possible needs of other Federal agencies are explored. It rarely happens, but if there are no known takers, the data is returned to the sender with thanks.

"NODC has over the years expanded and changed its activities, initially starting out by collecting whatever it could in whatever form it could and over the years winding up with a fairly sophisticated computerized data bank retrieval system, computer graphic capabilities, and other sorts of product-generating capabilities that enable us now to not only serve the very sophisticated users who just want all the data and all the numbers and all the details, but also people in the engineering community and other sorts of managerial roles where they want something synthesized, boiled down, and given to them so that they can make decisions as far as off-shore drilling, or construction or shipping or whatever interest they might have."

The speaker was James Churgin, Director of NODC's Information Services Division, the group that informs potential users about what data is available at the center that may be of interest to them.

"We like to deal specifically with the needs of the customers and have designed our programs for maximum flexibility so that when someone calls us and says 'I need something,' we try to find out what they are going to use it for and maybe advise them as to what the best sources would be here. And then we have some inventory systems that can query the data files specifically for what they need—the area, the time period, the ships, the depths, the kinds of parameters that they are searching for and say, 'Yes, here's the distribution of the data you requested. Is it enough for you to do anything with? Perhaps we can suggest other sources if that is not the case.' "

A staff member much concerned with the form the data is given is Robert Lockerman, chief of the Product Development Branch in Churgin's division.

"The data that we hold in the national archives are of enormous value," he said. "But they are only of value if somebody can use them and they can be assimilated by a human being. They are simply too voluminous to do anything with other than that. So we have to have them in some sort of form that a human can deal with and relate them to the real world. This means what we call here product development. It means that you have to have the data in either a statistical summary form, in a graphical form preferably, or some form that a person can sit down and actually use it and apply it to a problem that he or she is dealing with."

Often the agency can fill an order for information simply by taking previously compiled data "off the shelf" and with a minimum of effort shape it into what is being sought.

"On the other hand," said Lockerman, "if we don't have what a customer asks for, or if we have something that is not quite what the customer is asking for, we can modify it. The customer will, of course, have to pay the programming costs, the programmer's salary, and other associated monies, because we do the work on a reimbursable basis.

"If we have absolutely nothing that does what a person wants to do, we do a completely custom programming job for them, generate the product, and—if it's a general application that will be used by somebody else—add that to the open-ended file in the program library. This then becomes a new product that can be used off the shelf the next time."

Some customers are hard to please.

"Tell me all you know about the ocean."

That's the straight-to-the-point inquiry that NODC frequently gets from a school child—or maybe a class of 30 students. And the agency sends fact sheets which, while far from containing all the information known about the ocean, give the questioner at least a smattering of data and some leads on where to get more.

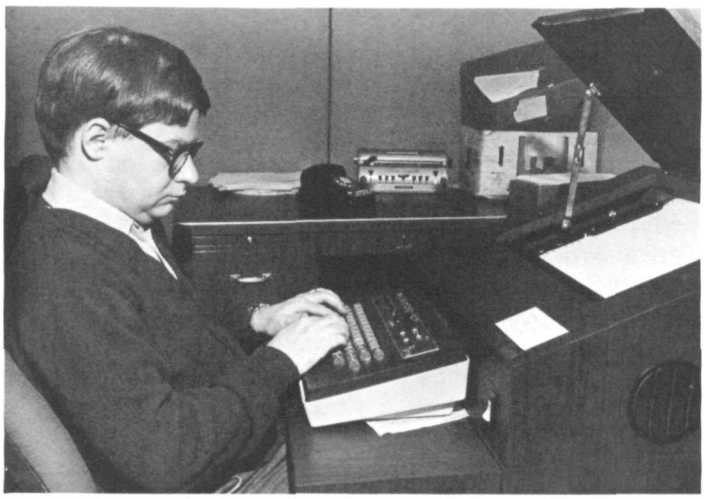
Henry Odum, an oceanographer in the User Services Branch, said the more typical customer is likely to represent private industry, NOAA or other Federal agency, academia, or foreign governments. In a typical year there will be around 4,000 requests for oceanographic data, one-third to one-half of which may be repeat customers. A recent sample shows the user variety:

- A meteorological consultant was provided current data around Colombo, Sri Lanka, for a port engineering study.
- A California firm requested temperature, wind, wave, and swell data for the area of Santa Cruz Island where an aquaculture facility was being planned.
- Oil companies were given sound velocity data for areas in the Gulf of Mexico and the Gulf of Alaska in connection with offshore oil exploration.

Before processing, expendable bathythermograph temperature-depth profiles must undergo analog-digital conversion. In the bottom right photo, a Braille computer terminal is used by blind NODC computer programmer Keith Levinson.

NODC receives oceanographic station (temperature-salinity) data collected worldwide from nearly 800,000 stations.

The center plans a major upgrading of its inhouse minicomputer facility so that all input processing and data quality control operations can be consolidated on one machine.



- The National Museum of Natural History of the Smithsonian Institution asked for near-bottom oxygen concentrations at 15 locations in the Atlantic Ocean to support a paleontological research project.
- A newspaper syndicate requested information on North Atlantic tropical cyclones.
- A Palo Alto, Calif., company ordered a complete ocean surface current data base in connection with work in ship routing.

In the present age of satellite remote sensing, NODC data are increasingly used to provide ground truth in verifying satellite measurements. A good example of the complimentary use of remote sensing data and direct ocean measurements took place in 1983 through the data exchange facilities of World Data Center A for Oceanography. On request through WDC-B for Oceanography in Moscow, WDC-A, Oceanography obtained chlorophyll data in the Baltic Sea for scientists at the NESDIS Satellite Experiment Laboratory. These data were collected onboard the Soviet vessel AJU-DAG by researchers from the Institute of Thermophysics and Electrophysics, Academy of Sciences of the Estonian S.S.R., Tallinn. In exchange, the Satellite Experiment Laboratory provided the Soviet scientists with U.S. chlorophyll data for the same area obtained by a satellite instrument called the Coastal Zone Color Scanner.

One of the agency's most popular products is its recreational brochures put out in cooperation with the Sea Grant program. These give summaries of air and water temperatures, winds, and waves in a number of coastal areas and contain advice on fishing, safety, marine publications, and related subjects.

NODC is helping to implement the National Ocean Pollution Planning Act of 1978 (P.L. 95-273), which called for a long-term effort to establish an Ocean Pollution Data and Information Network (OPDIN) among participating Federal agencies. It had been found that numerous government agencies were collecting data and information to serve their own programmatic goals, but fellow agencies and outside organizations were often finding it difficult to determine what ocean pollution data were available from Federal sources and how to obtain them. OPDIN was the instrument set up to do the job.

Ocean data that in years past would have taken hours to collect now can be taken in minutes, using new electronic instruments. Planned ocean sensing satellites will accelerate even more rapidly the rate at which ocean data accumulates. Other new technology, however, such as advanced minicomputers, data base management systems, and computer mass storage devices, are providing NODC the tools to cope with increases in both the volume of available ocean data and the demand for better, faster ocean data services. ■

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Early Year of the Ocean Events Score With Young People

The Year of the Ocean got off to a roaring start with early-March school science days around the nation designed to show students how their lives were affected by the oceans and how NOAA contributes to our understanding and wise use of the marine environment.

In Seattle, four NOAA ships and a display at the Pacific Marine Center drew 1,200 visitors. The Virginia Key Science Complex in Miami had approximately 1,300 visitors. In Charleston, S.C., 4,000 visitors toured the Southeast Fisheries Center, while in Bay St. Louis, Mo., over 300 people inspected the National Space Technology Laboratory. Select students from area schools were invited to the open house at the Southwest Fisheries Center at La Jolla, Calif., with about 160 visitors participating. In Washington, D.C., open house activities at Andrews Air Force Base and on the NOAA ship Researcher attracted approximately 3,300 students, and at Norfolk, Va., 500 visitors toured the Atlantic Marine Center. The National Marine Fisheries Service's Oxford, Md., Laboratory greeted 500 visitors and the Narragansett R.I., Laboratory had 250. In Honolulu, open houses at the Southwest Fisheries Center and Pacific Tsunami Warning Center drew approximately 600 visitors, and nearly 1,000 persons inspected the NOAA facilities at Anchorage, Alaska. In Boulder, Colo., roles were reversed as representatives from NOAA facilities visited area schools.

NOAA aircraft, ships, and other facilities drew thousands of enthusiastic kids to Year of the Ocean observances around the nation.

YEAR OF THE OCEAN
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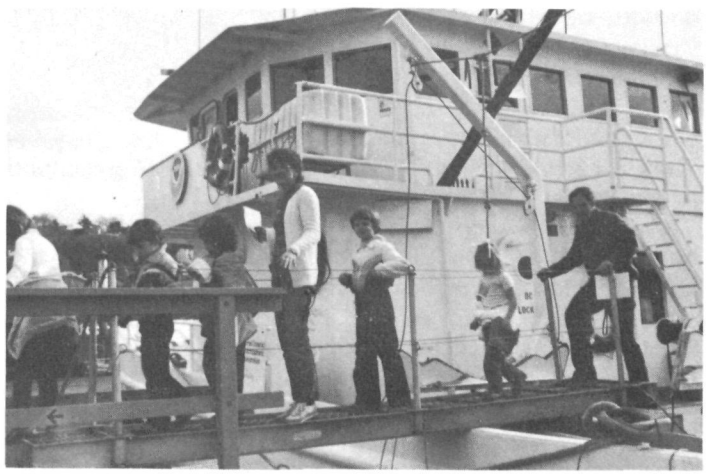
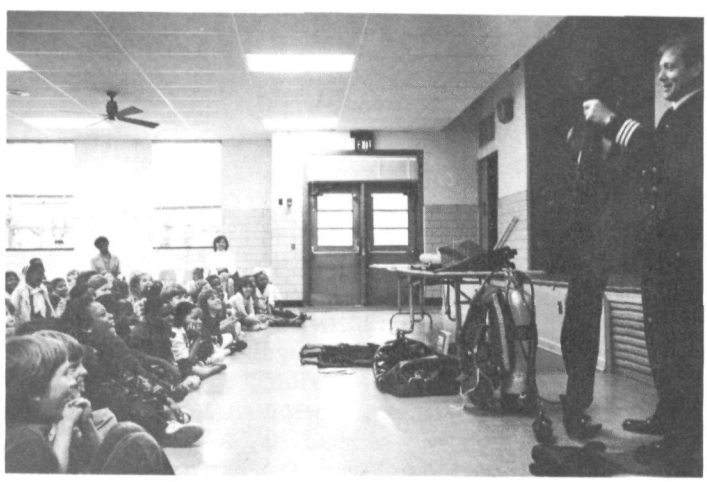




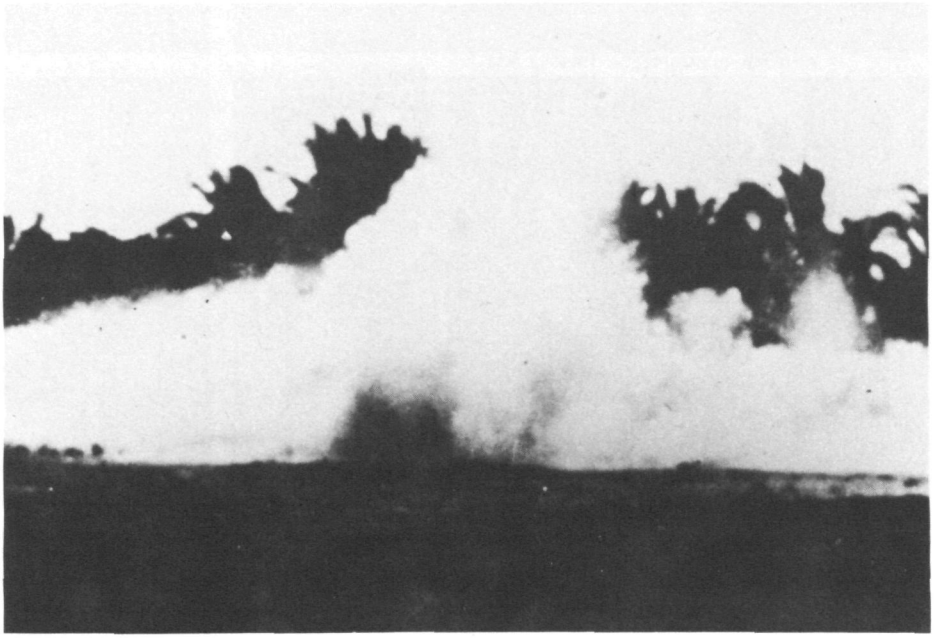
TSUNAMI:

A Wave Like No Others

Don Witten

"They are waves like no others. Speeding across the Pacific Ocean at 600 miles an hour, they can travel from Alaska to Antarctica in less than a day. Yet, they cannot be seen from an airplane or felt in a ship at sea. Strung out over the open ocean, they are only a few feet high with a hundred miles distance from crest to crest.

But when all of their speed and power roll into a harbor or onto a beach, such waves can become monsters, crashing down like a mountain of water as high as a ten-story building. Although often called tidal waves, they have nothing to do with tides. They are the dreaded "tsunamis," named by the Japanese who have suffered much from these killers waves. In Japanese, "tsu" means harbor and "nami" means great wave. Thus, the term "tsunami" means great harbor wave.



In 1946, a huge seismic sea wave roared ashore near the Putumaile Tuberculosis Hospital on the Island of Hawaii. The tsunami resulted in 173 deaths.

Tsunamis are generated by earthquakes occurring below or on the floor of the sea. Nowhere are these killer waves more prevalent than in the Pacific Ocean, which is encircled by a belt of frequent earthquakes and volcanic eruptions appropriately called the "Ring of Fire." Every island and coastal settlement in the Pacific Ocean area is vulnerable to the tsunami.

On April 1, 1946, a violent earthquake disturbed the northern slope of the Aleutian Trench, and triggered one of the Pacific's most destructive tsunamis in recent years. Waves measuring 100 feet high destroyed the lighthouse at Scotch Cap on Unimak Island, Alaska, killing five people within minutes after the quake.

It took about 5 hours for this deadly tsunami to reach Hawaii. The huge waves came out of the Pacific Ocean into Hilo Harbor without warning. When it was all over, Hawaii had suffered its worst natural disaster ever, with 159 dead and damage totalling more than $25 milliion.

But this tsunami would be one of the last destructive tsunamis to surprise Hawaii. By 1948 the United States established the Pacific Tsunami Warning system with its center of operations at the Honolulu Observatory at Ewa Beach. Here, a 24-hour watch is maintained to detect the first reactions of instruments thousands of miles away. These include seismographs to detect and locate earthquakes and tide gauges to detect the generation and propagation of tsunami waves.

The new Tsunami Warning System began paying its way when warnings of the November 4, 1952, tsunami in Hawaii prevented the loss of life, even though damage from the waves exceeded $800,000.

It was the Good Friday earthquake of March 28, 1964, that reinforced the need for a second Tsunami Warning Center. The epicenter, or area of origin, of the largest earthquake tremor ever recorded in North America, was in Prince William Sound, Alaska. The quake generated a major tsunami that swamped much of the Alaskan coast before the Honlulu Observatory could confirm that a deadly wave had been generated. It produced major damage in Alaska and Canada. Three Alaskan villages were completely destroyed, resulting in the death of 96 people before the wave reached Washington, Oregon, California, or Hawaii. Four people died in Oregon and another 11 perished in California. Warnings had helped keep the death toll from reaching the hundreds.

NOAA's Tsunami Warning System today consists of two warning centers: one at Palmer, Alaska, headed by Thomas Sokolowski and the other in Honolulu headed by Gordon Burton. The center at Palmer is responsible for issuing regional tsunami warnings for Alaska, Canada, and the west coast of the United States. The center in

Honolulu issues Pacific-wide watches and warnings for the United States and all other countries and territories in the Pacific Ocean.

"Our Tsunami Warning System today provides timely warnings to 18 Pacific coastal and island nations and territories, including the U.S.," said Tsunami Program Manager, Richard Hagemeyer, who is Director of the National Weather Service's Pacific Region with headquarters in Honolulu.

"It is truly an international service," added Richard Derycke, tsunami focal point at the facility.

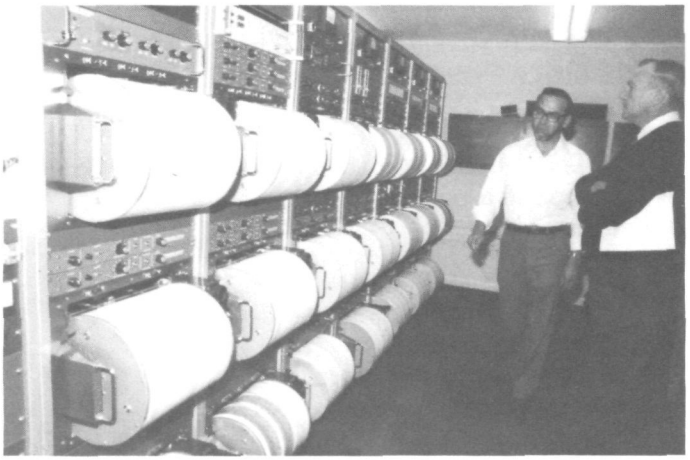
Both Centers depend upon a network of seismographs, which extend from Virginia to Shemya in the Aleutians, to detect earthquakes, and a Pacific network of tide stations to confirm the existence of a possible tsunami. Satellites, voice communications, and teletype systems are used in the collection of information and for the issuance of tsunami watches and warnings by each Center.

At the first tremor, alarms are sounded automatically at the Centers, based on information from participating seismographic stations. The immediate task is to determine the strength and epicenter of the earthquake. Although all tremors do not generate tsunamis, those generally registering above 6.5 on the Richter Scale of intensity often do produce the deadly waves.

Either Center will issue an instant tsunami warning calling for evacuation of areas within 3 hours tsunami travel time from the epicenter of strong earthquakes. At this time, the Pacific Center also will advise other Pacific nations of the possible danger until the existence of a tsunami is confirmed.

Both Tsunami Warning Centers then turn their attention to the tide stations. If no tsunami waves have been generated, the warning will be cancelled immediately. When the dangerous waves are detected, however, the warnings will be extended to the coastline of the United States and other Pacific countries. Estimated arrival times of the dreaded tsunami are then computed and issued in bulletins.

These sequential photos show the arrival of a 1957 tsunami at Laie Point on Oahu, Hawaii. The wave resulted in $300,000 in damage and 54 deaths.



Action in the National Weather Service's Alaska Tsunami Warning Center. The drums record seismic data, the first clue to tsunami formation.

The main benefit of NOAA's Tsunami Warning System is to give participants time to prepare for the waves arrival. Dissemination of watches and warnings is made to previously designated emergency organizations in each country, territory, or state. Local warning, evacuation, and other emergency procedures are then activated by designated emergency and relief organizations in the regions covered by the warning.

In 1965, the United Nation's Intergovernmental Oceanographic Commission (IOC) established an international coordination group for the Tsunami Warning System in the Pacific to provide close coordination and liaison between countries which share a mutual threat from the deadly tsunamis.

At the same time the IOC also established the International Tsunami Information Center at the Weather Service's Pacific Regional Headquarters in Honolulu. Directed by George Pararas-Caryannis, the ITIC conducts tsunami disaster surveys and serves as the focal point for historical records on the great wave events. These records are stored at the World Data Center-A located at NOAA's National Geophysical and Solar-Terrestrial Data Center in Boulder, Colo.

"At its ninth session last March in Honolulu, the International Coordination Group for Tsunami Warning System revealed that a number of Pacific Basin countries have accelerated the development of their local detection and warning systems because of recent tsunamis," said Bob Landis, head of the Weather Service's Marine Services Branch, who participated in the United States-sponsored meeting.

Tsunami damage at Resurrection Bay at Seward, Alaska, following the destructive 1964 Alaska Earthquake. The area received $14.6 million in damage.

During the meeting, NOAA demonstrated the value of its GOES-West geostationary satellite for increasing the tsunami warning time. In the demonstration, it required less than a second for a signal from an activated tide gauge to travel to and from the satellite, which is stationed 22,300 miles over the equatorial Pacific Ocean.

"NOAA satellites can help speed future warnings in the Pacific Ocean Basin by utilizing automated tide gauges," Landis said.

Tsunamis are relatively rare events, which have been responsible for some of the worst disasters in history. In 1868 and 1877 earthquake-generated waves devastated towns in northern Chile, and caused death and damage across the Pacific. The 1883 eruption of the volcano Krakatoa in Indonesia produced a tsunami that killed 36,000 people in the East Indies. Japan lost 27,000 lives to the wave of 1896, and 1,000 more to a tsunami in 1933. There have been hundreds more whose effects were less spectacular but which took many lives and did much damage.

In May of 1960, the most destructive tsunami in recent history was generated near Chile, killing 1,000 people in that country. Extensive damage was recorded in Chile, Hawaii, the Philippines, Okinawa, and Japan. Waves up to 35 feet high pounded the Hawaiian city of Hilo, leaving 61 dead and damage of more than $22 million. Without the 6 hour advance warning from the Pacific Tsunami Warning System, however, the death toll might have been much higher. Many of those killed in Hawaii and Japan had been warned but failed to heed the warning.

NOAA, through its Pacific Marine Environmental Laboratory and the World Data Center-A for Tsunamis, is now conducting a special project with Chile to place instruments in the immediate vicinity of Valparaiso within the next several years. The primary purpose is to establish a regional warning center for Chile which may serve as a prototype for other Pacific areas. These will be tied into the Pacific Tsunami Warning System in an effort that is being conducted in close cooperation with the ITIC.

"As deadly as tsunamis are, they are providing the impetus for all countries in the Pacific Basin to work closely together in meeting a common threat," added Landis. ■

The deadly earthquake-generated tsunami in 1946 wrecked a political party club house at Hilo, Hawaii.

Tsunami Safety

An earthquake's worst killer may come from the sea. When you hear a tsunami warning, you must assume a dangerous wave is on its way. History shows that when the great waves finally strike, they claim those who have ignored the warning.

Remember:

- All earthquakes do not cause tsunamis, but many do. When you hear that an earthquake has occurred, stand by for a tsunami emergency.
- An earthquake in your area is a natural tsunami warning. Do not stay in low-lying coastal areas after a local earthquake.
- A tsunami is not a single wave, but a series of waves. Stay out of danger areas until an "all-clear" is issued by competent authority.
- Approaching tsunamis are sometimes heralded by a noticeable rise or fall of coastal water. This is nature's tsunami warning and should be heeded.
- A small tsunami at one beach can be a giant a few miles away. Don't let the modest size of one make you lose respect for all.
- All tsunamis—like hurricanes—are potentially dangerous, even though they may not damage every coastline they strike.
- Never go down to the beach to watch for a tsunami. When you see the wave you are too close to escape it.
- Sooner or later, tsunamis visit every coastline of the Pacific. Warnings apply to you if you live in any Pacific coastal area.
- During a tsunami emergency, your local police and other emergency organizations will try to save your life. Give them your fullest cooperation.
- Stay tuned to radio, television, or NOAA Weather Radio during a tsunami emergency—bulletins from these media can help save your life.

Directions

Managing Our Marine Ecosystems

(Excerpts from NOAA Adminstrator John V. Byrne's keynote address to the Symposium on Variability and Management of Large Marine Ecosystems held by the American Association for the Advancement of Science, May 28, 1984.)

I want to talk this evening about the nature and problems of large marine ecosystems from the standpoint of a science administrator in Washington, D.C. The concerns of wise science administration overlap and are affected by your scientific concerns, but they are also different. Let me try to define some of these similarities and differences.

A man named Robert Giles neatly summed up one of the major differences when he wrote:

"The scientist, fully engrossed with the questions of uncertainty, of probability distributions and risk levels, and the immense unknowns of the next experimental phase of work, will not typically comprehend the equivalent intellectual working environment of the manager. That world is commonly counter-intuitive, very complex, uncontrollable. . ."

"In the extreme," he continues, "the scientist must act as if nothing is known; the manager must act as if everything is known. In all cases the manager must act soon, and the primary act is to decide."

• • •

Today we are focussing on the importance of the ocean, and the 12-month period beginning July 1 has been designated as the Year of the Ocean.

The objectives of the year include fostering a better understanding of the ocean's importance, and promoting a sense of stewardship among the public and ocean industry.

In his proclamation of the Year of the Ocean, President Reagan has called for "a heightened awareness of the essential role of the sea in the life and future of our nation. The Year of the Ocean will provide an excellent opportunity to examine our ocean heritage and our ocean future as we approach the twenty-first century."

That is public notice and support—and it is what you are all about, too. We who are deeply involved in Year of the Ocean activities hope very much that you in the scientific community will lend your time and talents to its programs.

• • •

Looking at large marine ecosystems from the standpoint of an administrator, I think it is fair to say that management so far has been chiefly regional in nature. It results from the fishery management councils, and other special purpose management actions of the Department of the Interior and the Corps of Engineers, plus state efforts. All of these benefit, however, from the research and monitoring projects within the recently designated Exclusive Economic Zone of the United States—projects that we in NOAA, among other agencies, have carried out in partnership with academic institutions, through Sea Grant, and with the private sector.

• • •

Delaware Bay is a prime example of an area where management has been almost entirely regional. Not per se a large marine ecosystem in the terms of this symposium, it is a large estuarine ecosystem that is a tributary, if that is the right word, of the ecosystem of the northeast Atlantic shelf.

Your colleague William Odum has called our attention to economist Alfred Kahn's phase "the tyranny of small decisions." Kahn pointed out that this is a common problem in market economics—for example, in the loss of passenger train service to Ithaca, New York. If it had come to a vote, most Ithacans would presumably have preferred to retain the service. Nevertheless—by their small, independent decisions to travel by automobile, airplane, and bus—they "decided" against the service. And no doubt complained when it was abandoned.

Well, Delaware Bay was a perfect example of this. Individual plants used the Schuylkill River—a tributary of the Delaware—as a dump. So did towns and cities along the two rivers. Farming and development added their loads to the waters. Oceangoing ships contributed their effluent.

There was never an overt decision that befouling the Bay, a major producer of fish and shellfish, was good public policy. But all the little decisions added up. By the end of World War II the once pristine estuary, fourth or fifth largest in the United States, had turned into one of the most polluted, and least productive, in the Nation. The annual oyster yield, for example, dropped from two million bushels annually to almost zero in the late 1950's. Weakfish, blue fish, flounder and shad populations also plummeted.

The Delaware Bay story, however, has—if not a happy ending, at least a reassuring new chapter. Regional management stepped in in the 1950's, and again in the 1960's under the aegis of the Delaware River Basin Commission and with the support of the Environmental Protection Agency. A massive cleanup took place. The major concern, and the major gauge of cleanup, was dissolved oxygen concentrations.

Improved sewage treatment plants and more stringent effluent standards in the urban Philadelphia area have resulted in a marked increase in dissolved oxygen levels in the upper estuary.

There is increasing public awareness of the potential damage to marine ecosystems from the impacts of pollution and overexploitation. But there's nobody in charge of prevention. The Congress has by legislation mandated responsibilities to many parts of the Federal government to deal with these issues. Responsibility for protecting the public from health hazards resulting from marine pollution resides with the Public Health Service, the Food and Drug Administration, and EPA.

The Corps of Engineers regulates water resource projects and assures unimpaired navigation in harbors and waterways.

Maps and charts come from the National Ocean Survey.

Protection of marine mammals is shared between the Marine Mammal Commission, the Department of Interior, and the National Marine Fisheries

Service. Marine birds are the responsibility of the Fish and Wildlife Service.

The Department of Energy has a piece, as do the Coast Guard and the Navy.

Virtually all of the living resources and habitat assessment and monitoring within the large marine ecosystems of the United States are the responsibility of NOAA and some of its main line components—the National Ocean Service and National Marine Fisheries Service for various management functions, and the fisheries service and the Office of Oceanic and Atmospheric Research for certain scientific services. I have alluded to our major research programs in fisheries, physical oceanography, and meteorology. We operate research ships and aircraft, a national undersea research network, and science programs designed to monitor changes within marine ecosystems of the Exclusive Economic Zone.

I attach great importance to trying to lessen the turf battles, and simple lack of communications, among various Federal agencies, so I'm making greater use of Memoranda of Understanding among the agencies. This is helping overcome institutional constraints to holistic management of the ecosystems, and may enable us to avoid what we might call the tyranny of small governmental decisions.

Each year we produce assessments of the major fishery stocks and their environments. We publish the nation's National Marine Pollution Program Summary, and we conduct joint studies with other agencies on problems of mutual interest. We are also exploring means for fashioning a national policy that will lead to total ecosystem management within the Exclusive Economic Zone.

We are also trying to meet the increasing demands for providing services to ocean users, which include the scientific community, industry, and individual citizens. Among these services are forecasts of ocean weather and climate, predictions of fish stock abundance, reports on bathymetry, water mass structure, circulation, and evironmental monitoring measurements at the site of marine mineral explorations. We're also concerned with adequately measuring and addressing the growing problem of coastal pollution and habitat loss.

• • •

The problems of coastal managers are illustrative of the differences between scientists and managers that I alluded to early on, as described by Robert Giles. This is particularly true in the case of our marine and estuarine sanctuaries. In designing regulations for the sanctuaries, our managers—many of whom have scientific backgrounds—must write rules without knowing all the facts.

The scientific work that is to be done in the sanctuaries will give the managers more of the data they need to write sound regulations—will identify information gaps and suggest alterations. But the regulations often have to come first. To this end, our managers have emphasized strongly and repeatedly that the regulations process is flexible, and the specific points in the regulations are—have to be—subject to change as more information is acquired.

Someone once said that to a nervous person, everything rustles. When our modest sanctuary management group talks of flexibility and the need for change based on further scientific data, powerful interests react in fright.

So we are far behind many nations, including many developing nations, in protecting our marine areas. The concept of protecting marine areas, such as our national marine sanctuaries, continues to spread in popularity and acceptability throughout the world. Developing nations have learned from our mistakes that to ensure long-term viability of fishing habitats, tourism, and genetic diversity, they must set aside marine systems for comprehensive management.

We in the United States have not learned this lesson. Although our National Park System is probably the world's finest, we have not translated the need for special area management into our ocean ecosystems, but still cling to the belief that protection of individual species will suffice.

We are deeply aware of pollution problems in our waters, and have mounted programs to monitor and study them. We cooperate closely with the Environmental Protection Agency, whose job it is to fight the contamination. We are of course aware of the growing concerns in other maritime nations of the presence of detectable levels of organochlorines, trace metals, and hydrocarbons in coastal waters.

I'm please to report that NOAA, through the National Marine Fisheries Service, will during 1985 participate in a monitoring program sponsored by the International Council for the Exploration of the Sea to evaluate the health of the marine environment over the entire North Atlantic area. And I'm delighted that we have scientists here from three European nations active in the Council's affairs—Denmark, the Netherlands, and the United Kingdom.

We are actively conducting research and monitoring of large marine ecosystems within the Exclusive Economic Zone. Ship operations during the forthcoming fiscal year will include extensive bathymetric measurement, fishery assessments, marine mammal assessments, and environmental assessments of the continental shelves off the northwest coast, Alaska, Gulf of Mexico, and east coast.

The program will also extend into the Central Pacific for exploration of sea mounts. It will be supported by 21 ocean-going vessels operating over a total of 4,251 sea days.

Oceanic deposits of polymetallic sulfides are among important recent discoveries of science that hold great promise for development. For example, French and American scientists have made detailed studies of the geology, fauna, and water chemistry of the large hydrothermal field in 2500 meters of water along the marginal fault system of the Galapagos Rift Valley.

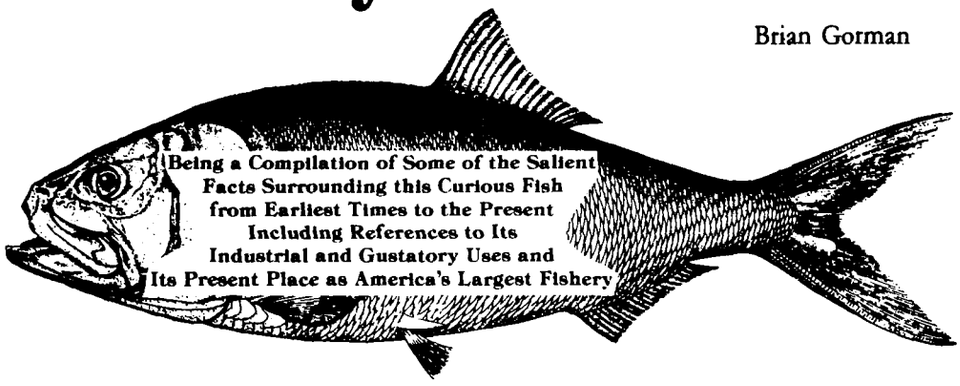
Such developments as deep tow techniques, ocean floor saturation photography, and manned submersibles have made possible many of the discoveries that have taken place.

To build on the basic knowledge, NOAA and the U.S. Geological Survey are undertaking a major survey program to map the Exclusive Economic Zone, using the NOAA ships Surveyor and Davidson. The first area to be mapped is the outermost continental shelf, the continental slope, and the upper rise off the coast of California.

The west coast will take about three years, and Alaskan areas will be started in 1986. In 1987, the ships will begin to alternate between the Hawaiian archipelago in the winter and Alaska in the summer. This will coincide nicely with the start-up of the satellite-based Global Positioning System, which will enable ships to know exactly where they are at all times without the need for establishing numerous temporary shore stations for reference. ■

A History of Menhaden

Brian Gorman



Picture if you will the lowly menhaden, *Brevoortia tyrannus* to the scientist, pogy, fatback, mossbunker, alewife, yellowtail shad, and a dozen other names to generations of East and Gulf Coast fishermen.

It looks like a fish, perhaps the archetypical fish, neither spectacular in size like a grouper nor impressive in shape like a marlin, nor grotesque in appearance like a monkfish. If you were to ask a twelve-year-old to draw you a fish, the chances are she'd produce a reasonable representation of a menhaden, although she wouldn't know it.

In spite of its being the quintessential fish, however, it has inspired no poetry. Izaak Walton, if he had known about the menhaden, would have ignored it. It takes no lures for it has no teeth. It would hardly have been a fit antagonist for Hemingway's Old Man. It weighs less than a pound and seldom reaches 20 inches in length. Neither could it have been described in terms to make the blood race like Sam Johnson's salmon in the Scottish highlands or Jacques-Yves Cousteau's sharks in the Gulf Stream. Nor is there any statehouse in the land above whose gilded legislative chamber is suspended a hollow copper sculpture of the menhaden.

Why then spend another moment on this creature whose appearance is so plain, whose flesh is too oily to be eaten (at least nowadays, although we shall see that this was not always true), and whose Narragansett Indian name—*munnawhatteaug*—means manure?

Let George Brown Goode, brilliant 19th century icthyologist, Curator of the U.S. National Museum, and onetime student of the noted Harvard University zoologist and geologist Louis Agassiz, rise to the menhaden's defense. In 1874, at the age of 23, the year after his appointment as an assistant at the U.S. Fish Commission, Goode was asked by Spencer F. Baird, the Commissioner of Fish and Fisheries for the United States, to write a monograph on the menhaden. He completed the work, which runs some 500 pages in "The Report of the Commissioner for 1877," in January 1878.

This is what he says:

It is not hard to surmise the menhaden's place in nature; swarming our waters in countless myriads, swimming in closely-packed, unwieldy masses, helpless as flocks of sheep, close to the surface and at the mercy of any enemy, destitute of defense or offense, their mission is unmistakably to be eaten. In the economy of nature certain orders of terrestrial animals feeding entirely on vegetable substances, seem intended for one purpose—to elaborate simpler materials into nitrogenous substances necessary for the food of other animals which are wholly or in part carnivorous in their diet. So the menhaden, deriving its own substance from otherwise unutilized organic matter, is preeminently a meat-producing machine. Man takes from the water annually six or seven hundred millions of these fish, weighing from two hundred and fifty to three hundred thousand tons, but his indebtedness to the menhaden does not end there. When he brings upon his table bluefish, bonitos, weakfish, swordfish, bass, codfish, what is he eating? Usually nothing but menhaden!

Maybe there's something about this fish worth examining, then. In fact, there is, for it turns out that the menhaden has served the United States at least as well, if not as romantically, as the cod and the salmon, the tuna and the lobster.

Two natural characteristics of the fish have made it the most widely-caught species in the nation and have contributed to its history. First, it is remarkably oily. Second, it is gregarious, congregating in countless schools approaching half a million individuals each, within a few dozen miles of the Gulf and East coasts. Its oiliness has made it commercially valuable and its schooling habits have made it relatively easy to catch in great quantity.

But, we are getting ahead of our story, for the menhaden's place in American history predates its use as a source of oil, and may have been first recorded as early as 1621. It was that year that an Indian named Tisquantum or Squanto shared some agricultural expertise with a small band of English Puritan settlers in Plymouth, who had barely survived their first winter in America, and were about to begin their spring planting. As Governor William Bradford recalls in his *History of Plimoth Plantation*, written in the 1630s:

> [The settlers] (as many as were able) began to plant their corne, in which service Squanto (an Indian) stood them in great sted, showing them both ye manner how to set it and how to dress & tend it. Also he told them, axcepte they got fish & set [the corn] with it (in these ould grunds) it would come to nothing; and he showed them y^{t} in ye middle of April, they should have store enough come up ye brooke by which they began to build, and taught them how to take it.

Other references, equally equivocal as to the identity of the fertilizing fish, appear throughout contemporary accounts of the early settlements in Massachusetts Bay colony. In 1628 Edward Johnson's pamphlet "Wonder working Providence of Sion's Saviour in New England being a relation of the firste planting in New England in the yeere 1628," is more specific as to technique but still vague as to species:

> But the Lord is pleased to provide for [the colonists] great store of fish in the spring-time, especially alewives, about the bigness of herring. Many thousands of these they used to put under their Indian corne, which they plant in Hills five foot asunder; and assuredly when the Lord created this corne, hee had a speciall eye to supply these his peoples wants with it, for ordinarily five of six grains doth produce six hundred.

By the late 1700s, the practice of fertilizing with fish had gone from anecdotal reports by Puritan observers who had no interest in identifying what species of fish they were using, to the scientific literature, in which the menhaden is identified by name. One Ezra L'Hommedieu reports in the *New York Agricultural Transactions* in 1792 that experiments made on Long Island "by using the fish called menhaden or mossbankers as a manure have succeeded beyond all expectations."

It was not until the early years of the nineteenth century, however, that the menhaden's chief attribute—its oil—began to be exploited. Like the whales, whose own exploitation was about to begin in earnest at about the same time, the menhaden produced a high-quality, valuable oil that had application in a wide variety of industries. It was used in tanning and finishing leather, as a vehicle for paints, in making soaps and lubricants, and in processing rope. Unlike the whale, however, the menhaden was far easier to catch, was more reliable in its late spring-early fall migrations up the East Coast, and didn't require a large capital investment in vessels and gear. But most of all, the return on the capital that was invested was considerably quicker than in the whaling industry: no four-year wait for a whaler to return to port; pogy boats fished from sunup to sunset and returned to port every day.

According to John Frye, writing in *The Men All Singing,* a book on the history of the menhaden fishery published in 1978, the first successful fish oil production took place in 1811 in Rhode Island. Picture, if you will, what one of George Goode's contemporaries writes about the two men who founded the Rhode Island company. The pair, Christopher Barker and John Tallman, had set up a couple of iron kettles along the banks of the Sakonnet River, near where it empties into Narragansett Bay. The sight—and the smell—must have been a memorable one, for, as our correspondent relates, "they boiled the fish in the pots or kettles and bailed the fish and contents into hogsheads, putting on top [of] the fish in the hogsheads pieces of board with stones on top, to press the fish down so that the oil would come on top," where it could be skimmed off.

The firm continued, with some improvements from its primitive earlier methods and with a three-year interruption following its destruction in the "notable September gales" of 1815, for thirty-odd years, expanding to factories in Massachusetts and Long Island.

By the end of the Civil War, as demand for menhaden oil increased, still more factories were built throughout New England and Long Island. A new fishery had begun.

At about this time "floating factories" began to appear as well, mostly on Long Island Sound. They had a twin advantage, according to Goode:

> They are usually built upon the hull of some old vessel and are towed from point to point, gathering the fish from the smacks and working them into oil and guano as they move. Two important objects are attained by the owners of floating factories: the objection to their business arising from the offensive odor is to a considerable extent removed [and] by following the movements of the fish time and expense are saved.

In addition to its growing use as a source of high-quality oil in industry, the menhaden at this time began to be used increasingly for other purposes as well, as Goode's reference to guano suggests. Not only were the fish scraps, or pomace, reprocessed into fertilizer, but they also began to be used experimentally as early as 1864 as food for livestock. Goode reports on a correspondent in Maine who told him of using fish pomace, "or the residuum of herring, after the oil is pressed out, [which] is greedily eaten by sheep, swine, and fowl; and probably pogy chum would be eaten as well."

Our State of Mainer also reported that "careful and observing farmers, who have fed it, assert that it is of equal value with good hay, ton per ton, and that its

Seining menhaden in Pecomic Bay, Long Island. (From Goode's 1877 report.)

value for manure is in no degree diminished by passing it through the living mill, and thus reducing it to a much more convenient state for applying."

By 1878, according to Goode's records, there were at least 76 menhaden oil and guano factories from the Chesapeake Bay north, including 19 along Peconic Bay in Connecticut and another 17 in or near Boothbay, Me.

Goode then provides, in one of a series of examples of his remarkable thoroughness throughout his treatise, an exhaustive analysis of the nutritive qualities of menhaden versus a variety of grasses, grains and other standard lifestock feeds. Not surprisingly, especially in view of the fact that lifestock feed is now the principal use to which menhaden are put, the pogy outperforms almost all other sources of feed.

"It is clear," he concludes, "that what our farming wants, to make stock-raising profitable, manure plenty and rich, and crops large and nutritious, is nitrogenous material of foods.

"One of the cheapest, most useful, and best forms in which this can be furnished is in fish products. In proof of this we have the testimony of both extensive experience and accurate experimenting."

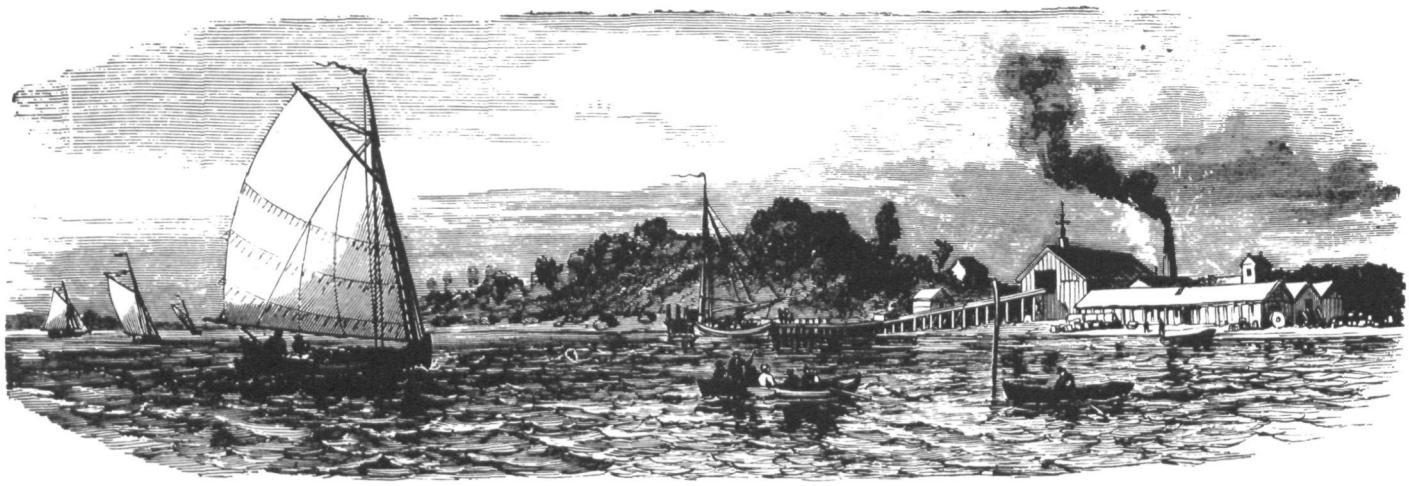
Goode also reports what can only be characterized as the most bizarre livestock feeding operation ever recorded, cows foraging for fish!

> The earliest account which I have met of fish as food for domestic animals is the following extract from the Barnstable [Mass.] "Journal," of February 7, 1833:
>
> "*Feeding Cattle on Fish.*—The cattle of Provencetown feed upon fish with apparently as good relish as upon the best kinds of fodder. It is said that some cows, kept there several years, will, when grain and fish are placed before them at the same time, prefer the latter, eating the whole of the fish before touching the grain. Like one of old, we were rather incredulous on this subject, till we had the evidence of ocular demonstration. We have seen the cows at that place boldly enter the surf, in pursuit of the offals thrown from the fish boats on the shore, and when obtained, masticate and swallow every part except the hardest bones. A Provencetown cow will dissect the head of a cod with wonderful celerity. She places one foot upon a part of it, and with her teeth tears off the skin and gristly parts, and in a few moments nothing is left but the bones."

Modern menhaden fishermen use mechanized methods.

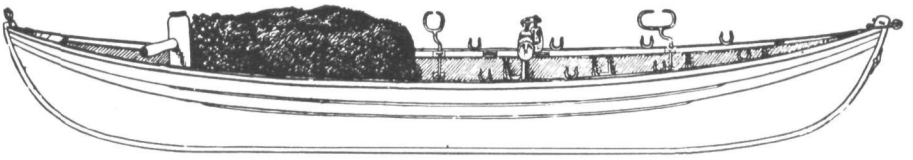
Perhaps no more remarkable than the image of cows wading into the surf in search of some fish, is the fact that for much of the nineteenth century the menhaden was used as a table fish and apparently consumed with as much gusto by people as our Provencetown cows consumed their fish.

"When perfectly fresh," asserts Goode, "[menhaden] are superior to most of the common shore-fishes. . . . The Maine fisherman finds his breakfast of fried pogies both substantial and palatable. I can testify from personal experience that a bony-fish [i.e., menhaden] chowder is not to be despised."



A 19th Century menhaden processing factory at Napeague, N.Y.

Menhaden by the ton.



An 88-foot seine boat of the mid-1800's.

Typically the menhaden was either sold fresh in local markets or salted and shipped inland or to the West Indies. In 1871 a New York company began a profitable enterprise canning menhaden in olive- or cottonseed oil as a replacement for the European sardine, and by 1873 the company was selling some 350,000 cans annually.

Even the nineteenth century equivalent of Madison Avenue must have gotten into the act, for Goode reports one company in Port Monmouth, N.J., selling canned menhaden in spices and vinegar under the names "Shadine," "Ocean Trout," and "Amerian Clubfish." O tempore, o mores!

This same period also saw the menhaden put to use as the baitfish in the mackerel, haddock, and codfish fisheries off New England and the Canadian Maritimes, being the fish of choice in preference to herring or clams. Goode estimated that in 1877 about 80,000 barrels, containing some 26 million salted menhaden, were used in the Grand Banks fisheries.

So desirable, in fact, was the menhaden as a baitfish, that the British Government, whose Canadian colonies were at a disadvantage being either forced to buy American menhaden at a premium or to use inferior baitfish caught off Canada, became concerned. U.S. fishermen were simply catching more fish than the colonists, perhaps because of the quality of their bait, and the British embarked on a campaign—not particularly successful—to convince their fishermen to "buy British." Charges and counter-charges flew between the American and British embassies and there was even talk of possible Congressional action forbiding the export of menhaden bait.

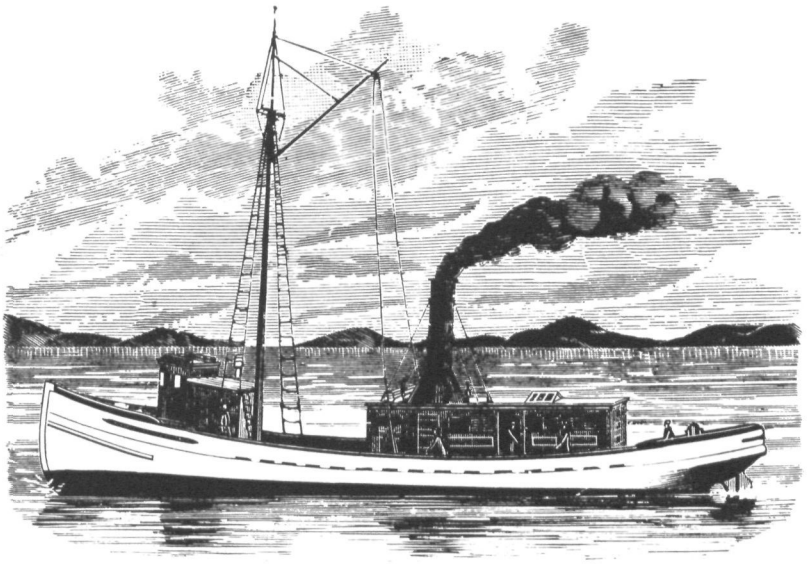
There is no longer a large menhaden baitfish fishery. And nobody seriously considers the menhaden as a foodfish anymore, although its oil has been used by Europe for years in the manufacture of margarine and NOAA's National Marine Fisheries Service is about to petition the Food and Drug Administration to allow similar use in the United States.

Other aspects of the menhaden have changed little, however. It is still enormously valuable as a source of oil and meal. Last year the U.S. produced a record 386 million pounds of menhaden oil, worth almost $65 million. Production of menhaden fish meal and scrap—George Goode's pomace—was also high: 316,000 tons worth about $112 million.

The method of catching menhaden has undergone little change either. Goode's description of purse seining, in which a school is encircled in a net, which is in turn "pursed up" to form a small area or bunt of the thrashing, greenish-bronze fish to be bailed into the waiting mothership, would be perfectly familiar to a modern pogy fisherman. His only advantage is the use of an airplane for spotting the schools and a "power block" that hauls in the slack net using hydraulic power instead of the backs of a dozen fishermen in the sein boat.

Even Goode's prediction of abundance, made more than a century ago, seems remarkably accurate. "There is no evidence of a decrease in the abundance of menhaden," he wrote in 1878, "during a period of fifteen or more years of fisheries conducted on an immense scale. It seems, therefore, that no one can reasonably predict a decrease in the future."

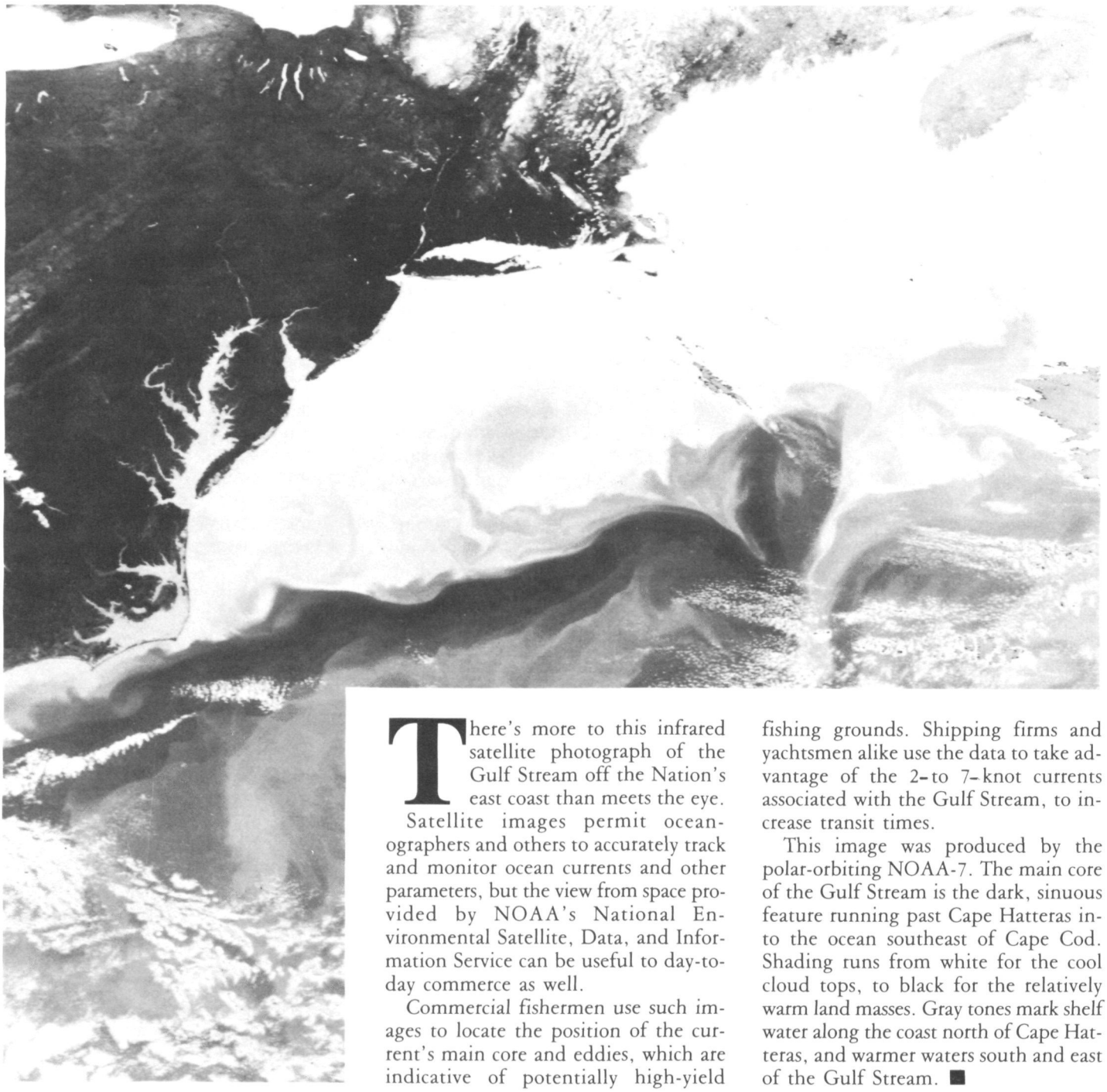
In recent years the American menhaden fishery has grown to staggering proportions that even George Goode might not have foreseen. It is by far the largest volume fishery in the country, involving hundreds of fishing boats, thousands of fishermen, and millions of dollars. Almost *half* the fish landed in the United States in any given year are menhaden. And 1983 proved a banner year for menhaden, with record landings of 3 billion pounds worth $119 million, although fishery scientists think it will be impossible to sustain such high landings for long.



A menhaden fishing steamer.

VIEW FROM SPACE

NOAA-7 Takes Ocean's Temperature



There's more to this infrared satellite photograph of the Gulf Stream off the Nation's east coast than meets the eye.

Satellite images permit oceanographers and others to accurately track and monitor ocean currents and other parameters, but the view from space provided by NOAA's National Environmental Satellite, Data, and Information Service can be useful to day-to-day commerce as well.

Commercial fishermen use such images to locate the position of the current's main core and eddies, which are indicative of potentially high-yield fishing grounds. Shipping firms and yachtsmen alike use the data to take advantage of the 2- to 7-knot currents associated with the Gulf Stream, to increase transit times.

This image was produced by the polar-orbiting NOAA-7. The main core of the Gulf Stream is the dark, sinuous feature running past Cape Hatteras into the ocean southeast of Cape Cod. Shading runs from white for the cool cloud tops, to black for the relatively warm land masses. Gray tones mark shelf water along the coast north of Cape Hatteras, and warmer waters south and east of the Gulf Stream. ■

A Career For Patrick Mead

Patrick Mead inspects the famed Atlantic Marine Center landmark, a 19th century cannon taken from an unidentified wreck off Lynnhaven, Va., by the NOAA ships Rude and Heck in 1971.

Jack Stringer

"It was mostly hands-on experience," said the 17-year old student from Virginia Beach who was aboard the NOAA Ships Rude and Heck to learn about wire drag operations in the Chesapeake Bay.

"I worked on the ship's computer and went to Thimble Shoals to help install batteries for an antenna used to get a fix on longitude and latitude."

These were normal if not daily activities performed by the crew of the two NOAA ships that chart and search for underwater obstructions. But for Patrick Mead, one of 40 gifted students selected for an intensive 18-week program designed to increase their career perceptions, his participation was of major significance.

Mead, an 11th grade student at Green Run High School in Virginia Beach, was a special guest at NOAA's Atlantic Marine Center last spring. AMC Director, Rear Adm. Wesley V. Hull, who shared his time and knowledge with Mead, considered the young student's visit "very beneficial, especially with the Year of the Ocean which calls for NOAA's participation in educational activities."

Mead is in the upper 3 percent of his class which made him elegible to enroll in the Virginia Beach City public school program called CAPS, Career Awareness for Precocious Students.

"Contrary to popular myth," said L. W. Skip McLamb, CAPS project coordinator, "gifted students are not making it on their own." Surveys have indicated that the gifted student, often talented in several academic areas, faces a difficult task in selecting the right career.

"Some of the students are vague; others are dead set," said McLamb. "We try to focus in."

When selected for the CAPS program, the students are interviewed to identify their general career perceptions. The next step is to find community professionals, called mentors, who are willing to give their time and to share their experiences without remuneration.

"We have had tremendous support from the community," said McLamb. "And the experiences of the students have been varied, realistic and extremely beneficial. Individually, the students' experiences have ranged from observing brain surgery, working in a hospital emergency room, accompanying a trial lawyer to court, to filling out medical insurance forms.

"Our goal is for the student to experience all aspects of a career," McLamb said. "The exciting and the mundane; its rewards and its frustrations."

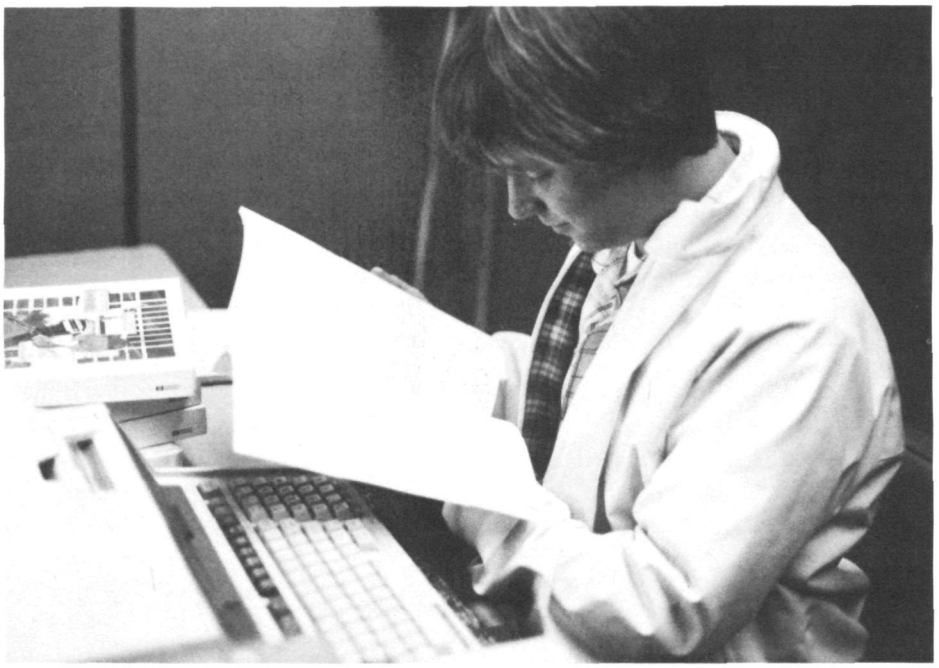
It was Mead's interest in a career in marine science that caused McLamb an unexpected obstacle. Although Norfolk is a major commerical seaport and Navy facility and the home of nationally recognized oceanographic educational establishments, he was unable to find a community professional who would provide Mead with a first-hand career experience in marine science.

"The Navy's career opportunities center on the ocean engineering field, and that did not interest Mead," McLamb said. "At a university, we had a student whose ocean environment career was defused because his mentor was required to spend an inordinate amount of time on paperwork and not enough time in the field."

Marilyn Feher, a counselor for the CAPS program, suggested NOAA. Feher, who had attended one of the numerous open houses at the Atlantic Marine Center, believed that if an apprenticeship arrangement could be worked out with Mead and a NOAA professional, a realistic concept of a career in marine science could be obtained.

It was a television program featuring Jacques Costeau that influenced Mead towards a career in marine science. The exotic locales, diving and searching for ancient artifacts and treasure, using space-age diving bells and underwater sleds—all interwoven with momentary glimpses of well-equipped Riviera laboratories—and bathed continuously in sunshine while living aboard a

Kirk Havens welcomes Mead to the AMC calibration lab where he received hands-on experience with the Marktech CDT, an instrument that measures conductivity, temperature, and depth; the B-8 plotter used for shoreline mapping; and a special computer hydrographic program that tested expendable sound velocity probes.



research vessel named after a sea nymph in Greek mythology, was as fascinating a career as any young man could hope for. Mead even studied French. And during his Christmas vacation, he visited Clearwater, Fla., where he explored nearby underwater caves and swam with the manatees.

Feher contacted NOAA to discuss the possibility of finding an appropriate mentor who would serve as an advisor, guide, teacher, and role model.

When a mentor is found, the student is required to spend at least 45 hours on the job. He must keep a log of his work experiences and attend 30 hours of evening seminars where he discusses his career objectives and the field he is investigating. He earns 1/2 credit a semester.

The two counselors in search of a mentor found a receptive person when they contacted Admiral Hull at AMC, who turned the actual scheduling of Mead's activities over to Charles B. Ellis, chief of the Center's Program Services Division.

"Mead was not just a warm body in the way," said Ellis. "He was actively involved in our laboratory and field operations."

The following observations from Mead's log indicate just how much the young man was involved:

Feb. 17:

Mr. Byrd introduced me to one of the field men who plot points on charts so photogrammetric work can be done. He taught me what all went into scaling a model and the process in making one.

Feb. 21:

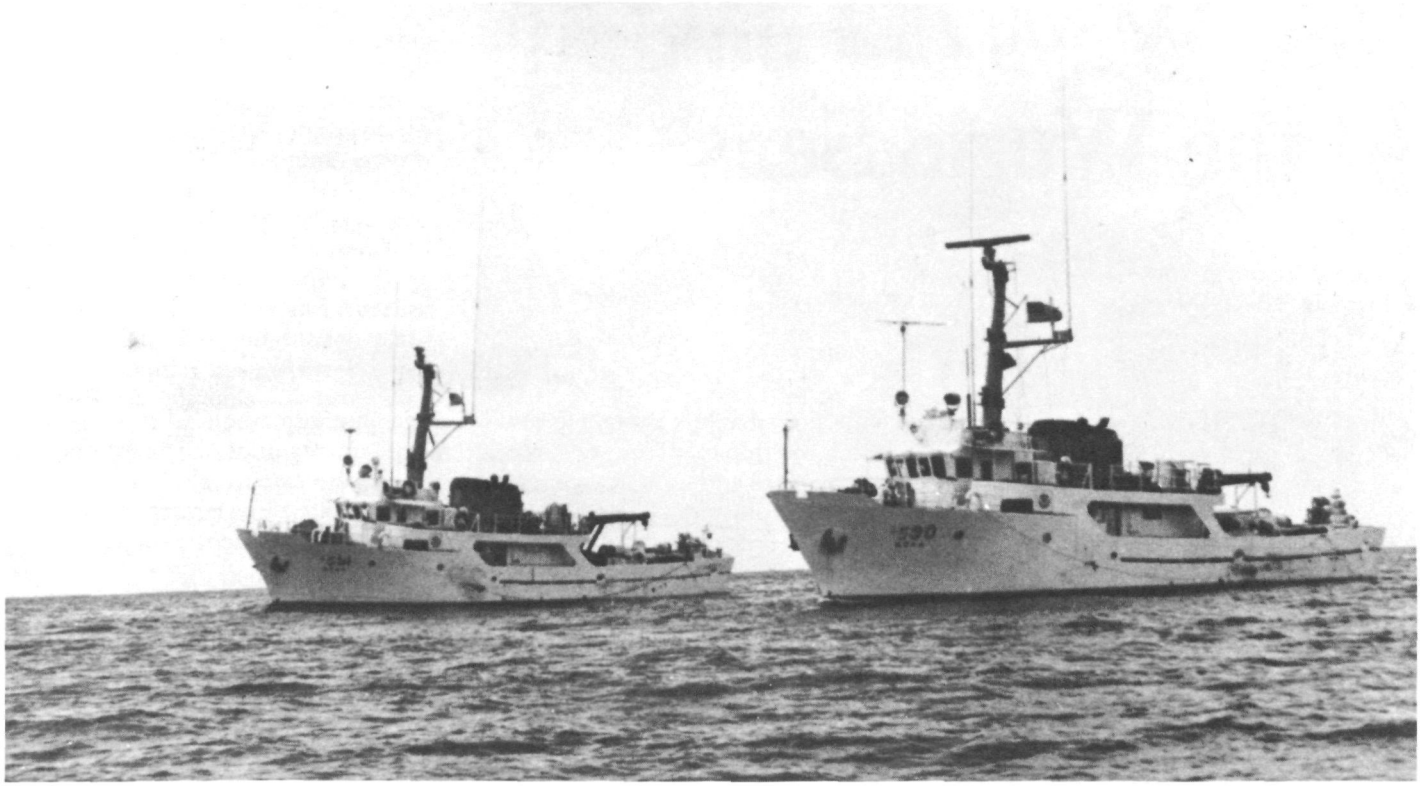
Today I helped with the layout sheets of Penobscot Bay. We plotted rock obstructions and other hazardous marine objects.

Feb 22:

Did the same thing as yesterday. This was the funnest day because today they asked for my opinion and they like the one I gave them. I still don't know how I'm going to make this interesting for someone else, but if a student reads this, let me just tell you that it is very fun work.

March 14:

Worked in the oceanographers' lab calibrating equipment such as thermometers, depth and pressure gauges, and conductivity meters. The two guys I worked with had



Mead gained first-hand career experience aboard the Rude and Heck, NOAA's two wire drag ships used to locate underwater obstructions.

just gotten out of Old Dominion University three years ago, and had gotten hired by NOAA.

March 21:

Tested the temperature all the way down to zero° C. They made me stick my arm in the water to get a water sample. My arm became very numb.

March 27:

Got to use the Sippican test model and computer. The reason they're testing this device is to see whether it really will save money.

March 30:

Met with Lt. Navarro who is the head of the diving organization at NOAA. We discussed qualifications for dive school.

April 11:

Met with Mr. Ellis to discuss plans for my trip (2 days) on the NOAA vessels the Rude and Heck, The major thing I needed was an emergency medical form to give the CO the right to authorize medical care.

April 16:

The ships were supposed to get underway at 10 but some over calculation of fuel was dumped over the side and the ships had to wait for the Navy to come and break up the fuel but when the Navy got there, they said it wasn't enough to worry about. So instead I went out and calibrated a latitude and longitude machine plus transported batteries to the Thimble Shoals' lighthouse for the latitude and longitude antenna to run off of.

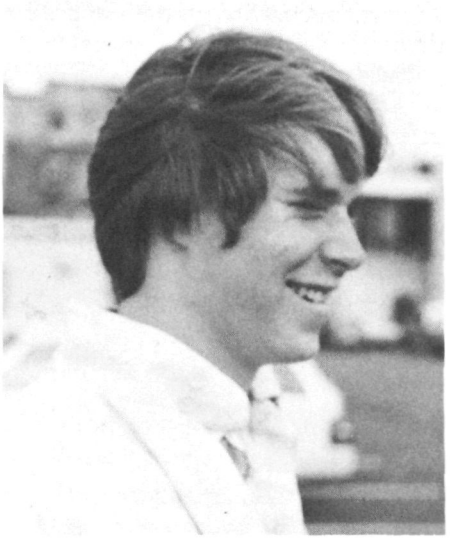
April 17:

Went out today to side scan for an alleged sunken vessel with its mast protruding out of the water. Had an image on the printer but was not able to determine if it was a craft or not. Some depth—sensor—printer malfunctioned, but other than that no problems.

Mead's apprenticeship at the Alantic Marine Center has been completed. This fall he expects to gain additional experience in the field of zoology, another career interest ("It would be neat to work at the zoo"); and next year, perhaps he'll seek experience in the field of music where his 6 years of studying the clarinet has opened still another career possibility.

"When there are motivated, adept, and interested students paired with willing, interested, and able professionals, the outcome is surely success," said McLamb who considers Mead's experience at NOAA's Atlantic Marine Center an "exceptional opportunity for him to make a realistic and prudent career choice."

"This was the first year we participated with the gifted and talented program," said Adm. Hull. "Even after the Year of the Ocean ends, I hope we will continue to work with the Tidewater educational system in this effort to be a positive influence in a young person's life." ■



New Ways of Looking At the World Seas

William J. Brennan and
William H. Hooke

"There is a tide in the affairs of men . . ." Some 400 years ago, during a period historians have labeled "the Age of Exploration," Shakespeare penned these words for the character of Brutus in the tragedy *Julius Caesar.* The 1500's was a time when men such as Cabot, Columbus, daGama, Magellan, and others were sailing to all corners of the globe, and each return of their ships brought excitement and announcements of new discoveries.

There continues to be "a tide in the affairs of men," The oceans remain as a major force shaping the planet and the geophysical processes operating on it, with fundamental implications for every living creature. Throughout the last several hundred years, however, despite a steady stream of breakthroughs in our understanding of oceanography and marine geophysics, the general public has come increasingly to take the oceans for granted.

All that is about to change. A number of trends are at work today which will mitigate existing widespread complacency and ignorance, increasing public interest and awareness in the oceans to an extent unmatched since Shakespeare's time.

The oceans' influence on world grain harvests is a case in point. The productivity of global agriculture depends in part on accurate, reliable climate outlooks for the upcoming growing season. If farmers could be told in advance, for example, whether a given growing season in their respective areas were to be "long-hot-dry" or "short-cool-wet," they could plan their grain selection, planting, irrigation and harvesting strategies accordingly, with corresponding gains in grain production.

Such forecast capabilities, while not yet in hand, are at least in prospect through improved understanding of the teleconnections that link changes in conditions on the tropical oceans to subsequent changes to atmospheric—climate—conditions worldwide. Thus, the key to developing operational climate forecasts and seasonal outlooks shifts to ocean observations: global coverage with measurements of sea surface temperature, sea ice extent, winds and surface stresses. And every farmer and citizen becomes a constituent or advocate for ocean nowcasting.

Vulnerable offshore drilling platforms depend on nowcasting.

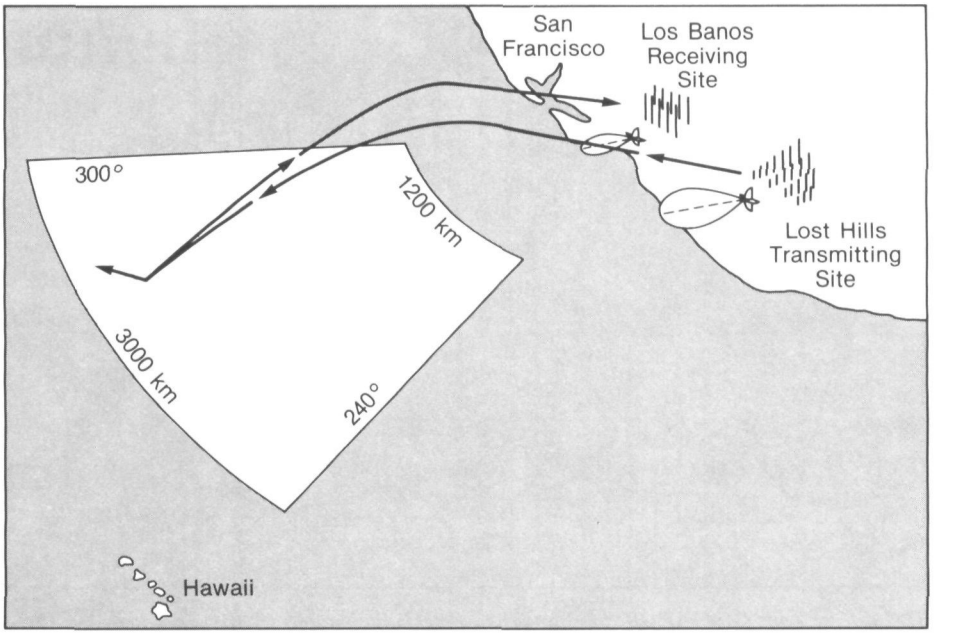
The search for energy, similarly, will be intertwining with the oceans and what is transpiring on their surfaces. By the end of this century the United States, it is estimated, will spend approximately *half a trillion dollars tapping energy* reserves from the Alaskan offshore. Even today, offshore oil and natural gas operators have enormous requirements for accurate ocean information. They need data on ocean waves and currents for safe design of oil production platforms, and accurate nowcasts and short-term forecasts not only to ensure the safety of platform crews and support operations, but also for guidance on conducting drilling operations, which in some cases are especially sensitive to sea state conditions.

By the year 1990, demographers tell us, 75 percent of the U.S. population will live within 50 miles of the Great Lakes or ocean shoreline, exposed to the ravages of severe weather in all seasons—heavy rain and winds from winter storms, tropical cyclones and hurricanes, and the storm surge and the flooding associated with these. Here, again, the availability of accurate ocean information is important, and in a very personal sense.

There are others dependent upon nowcasts and short-term ocean-related forecasts: marine transportation both at sea and in harbor, port facilities operators with their wind-critical gantry cranes, harbor pilots whose activities are influenced by wind, wave and tide conditions. Fishermen need, in addition to accurate forecasts both of weather and sea state, ocean information advising them of the best locations of productive fishing.

Even the quality of the air around us has an ocean connection. The two greatest uncertainties in air quality meteorology today are, in fact, oceanic in origin. The first is the impact of fossil-fuel consumption on global warming. The major uncertainty in all the CO_2 budgets is the nature and extent of CO_2 exchanges between the atmosphere and oceans. Similar uncertainties apply with regard to the acidity of rain over the continents, with recent research showing that the oceans can be major sources of reduced sulfur compounds in the atmosphere that can be precursors to acid rain.

Extraordinary progress by scientists from NOAA and elsewhere has been made in developing new tools for monitoring conditions on the Earth's oceans and in the marine atmosphere.



Skywave radar in California "sees" a 4-million-square-kilometer area of ocean by bouncing radio-frequency energy waves off the ionosphere.

Moored buoys have been augmented by monster buoys and drifting buoys which provide information on conditions on the open ocean. Shore-based radar systems now monitor offshore weather, and their capabilities are being enhanced by the introduction of digital displays and Doppler measurements of storm winds. Development by NOAA scientists at the Environmental Research Laboratories of the Profiler system for providing continuous vertical profiles of temperature, humidity and wind promises to improve weather monitoring and forecasts for coastal areas.

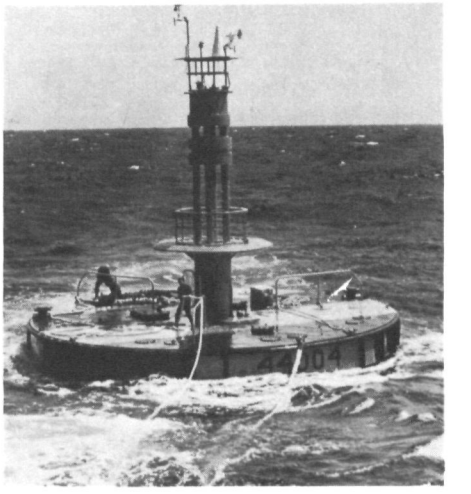
New NOAA-developed communications systems such as ARGOS and the GOES satellite-based data collection platform system permit real-time acquisition of meteorological and oceanographic data from ships of opportunity. Additionally, expendable bathythermographs, deployable from ships or from aircraft, have expedited and enhanced interrogation of the ocean depths.

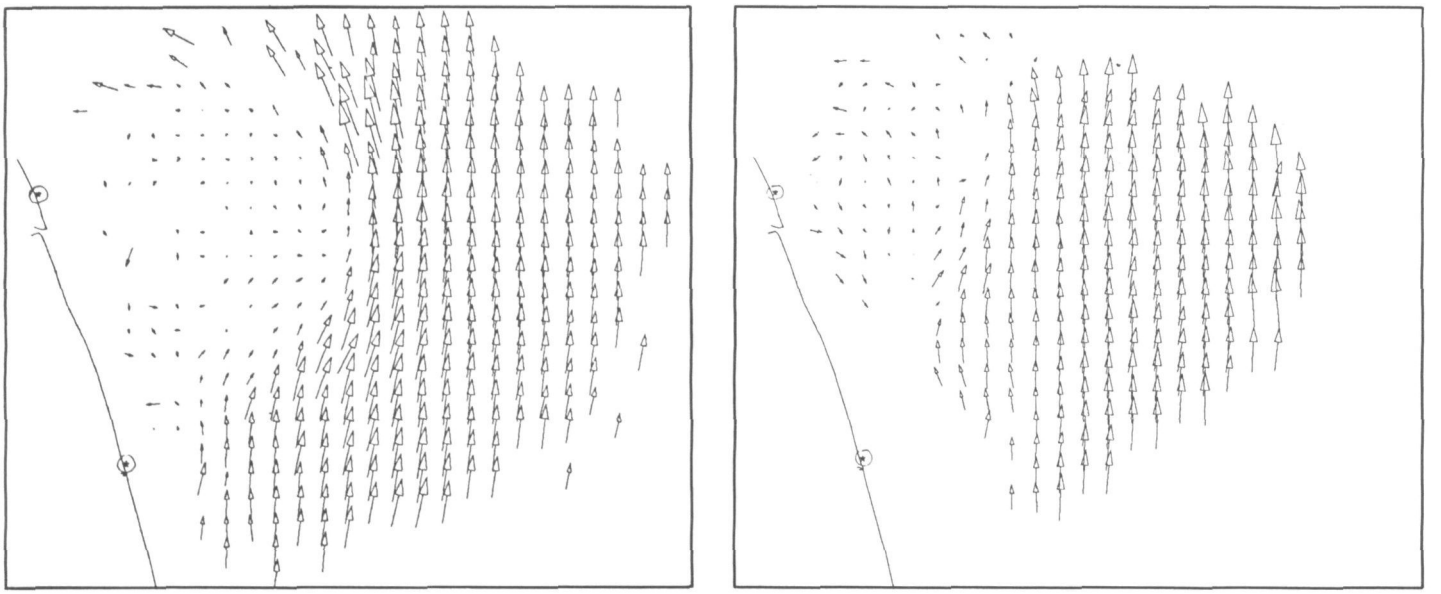
The simple fact, well recognized in NOAA research laboratories, is that proliferating in-situ techniques for ocean measurement will not keep pace with rapidly growing requirements for global coverage and for time and space resolution in ocean data. The expense of deploying, calibrating, operating and maintaining in-situ sensors in the harsh ocean environment, and the difficulties inherent in the logistics and telecommunications for sensor networks, preclude their expansion to any significant degree. Although such sensors will continue to play an important role in the foreseeable future, they must be augmented by remote sensing methods.

A number of efforts towards this goal being conducted at NOAA laboratories and elsewhere show significant promise.

Several microwave instruments—the scatterometer and the synthetic aperture radar among them—are looking at the oceans in new ways, providing information on wave height, wind speed and sea ice. Optical remote sensors are being shown to have the capability of delineating ocean fronts, separating water masses of differing temperature and biological activity.

Localized, but detailed, remote sensing may be accomplished by data buoys.



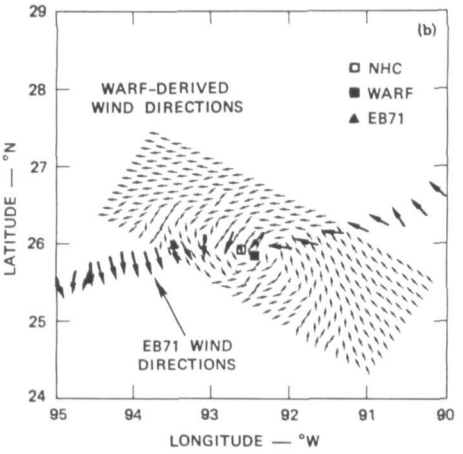


Two plots from CODAR show changes in the Gulf Stream off the Florida coast. At left, a large eddy with a convoluted current along its western side appears. South bound shipping would want to avoid this feature. Twelve hours later (right) things are more stable.

In addition to these instruments, most commonly flown on satellites, there are a variety of others, of higher diagnostic power, which are being flown on research aircraft, both to evaluate the performance of the satellite-borne sensors and to conduct ocean remote sensing investigations in their own right. These include the radar ocean wave spectrometer, the surface contour radar, the airborne oceanographic lidar and the sidelooking airborne radar.

Ocean remote sensing also can be accomplished from fixed sites on shore, providing information on ocean surface currents, significant wave height, and wave direction. So-called "ground wave" radars scan areas as far off shore as 50 miles or more, while "over-the-horizon" radars—by bouncing radio waves off the ionosphere—can scan ocean areas thousands of miles in dimension. From just two continental locations—Idaho and Kentucky, for example—this "sky wave" radar can monitor the waters of the Atlantic, Pacific and Gulf of Mexico.

Hurricane Anita in the Gulf of Mexico as seen by California-based over the horizon radar.



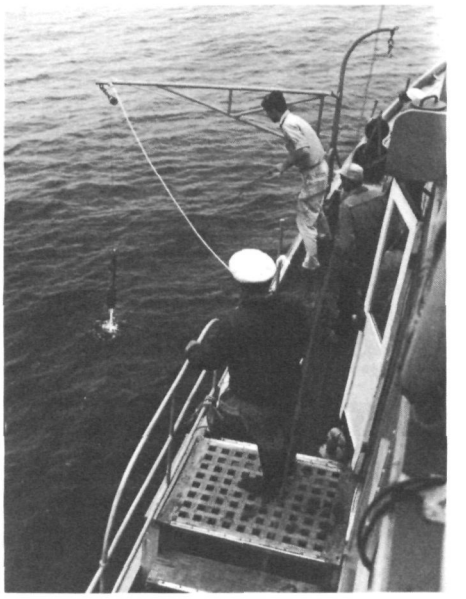
Another developing technology for coastal monitoring is CODAR, developed at ERL's Wave Propagation Laboratory. This system, utilizing dual radar sites and highly sophisticated computer processing of radar echo returns, has potential use in providing current, wind and wave information to off-shore oil facilities, coastal shipping, Coast Guard search and rescue operations and the like.

The remote sensing techniques mentioned provide information on ocean surface conditions which are most relevant to nowcasting, forecasting, and long-range weather prediction and seasonal climate outlooks. A complete specification of the ocean state, required for forecasts of climate change and needed for a variety of research studies, demands information on ocean temperature, salinity and circulation at all depths.

Acoustical remote sensing systems are making this possible. Because the travel time of acoustic waves in water is related to temperature, salinity and currents along the wave propagation path, it is possible to use arrays of acoustic sounders and receivers to monitor controlled transmission of sound along many ocean pathways and, through appropriate mathematical techniques, infer the temperature, salinity and currents of the ocean.

Shakespeare's Brutus despaired of riding the tide of human affairs at its flood. Not so NOAA researchers. With imagination and perseverance they continue development of new tools for ocean measurement, enthusiastically accepting the challenges surfaced by the flood of national demands for ocean information. ■

Ocean soundings by more conventional means are still the scientist's main source of information.



An Old-Fashioned New England Clambake

Summertime is the season for outdoor cooking, but unfortunately hi-tech has insinuated its way onto a lot of American al fresco eating: gas-fired grills, electric rotisseries, smarmy aprons with matching cutsie paper napkins, and a whole lot of culinary red tape. If you live fairly near the seashore or at least have access to several bushels of clean, rock seaweed, you might want to try preparing a clambake, an outdoor pit cooking method that involves a bit more work than squirting lighter fluid on some charcoal briquettes, but is a whole lot more rewarding too.

Relative quantities of food—and even the variety of food, except for the clams—obviously aren't critical in a clambake. If you'd rather skimp a bit on the lobsters in deference to an extra two or three chickens, do so. You might also want to add a portion of fish, like cod or haddock, as well. But plan on a bake that will feed at least 20. Although it's fairly easy to cook for more, preparing a clambake for much fewer than 20 almost isn't worth the effort.

For twenty servings have ready:

200 soft-shell clams (or 50 hard-shell clams), scrubbed clean
4 dozen ears sweet corn, with one or two layers of husk left on
4 broiling chickens, whole
5 pounds hot or sweet Italian sausage links
2 dozen medium boiling potatoes (or a dozen boiling potatoes and a dozen sweet potatoes)
20 1½ pound lobsters (or 60 blue crabs or similar quantity other local crabs)
3 to 4 bushels clean, fresh rock seaweed, left to soak in seawater for at least an hour
Tarpaulin, about 5 feet by 5 feet

Begin about 4 hours before you plan on eating by digging a pit about 1½ feet deep and 3 feet on a side. Line it, sides and bottom, with smooth, round rocks. Build a substantial hardwood fire in the pit, and keep it burning for about 3 hours to thoroughly heat the rocks. Remove the hot embers from the pit and immediately line the bottom with about 6 to 8 inches of wet seaweed. On top of the seaweed layer place the hard-shell clams, and then in order, the potatoes, the sausage, the lobsters, the chickens, the sweet corn, and (if you are using them) the soft-shell clams.

Cover the food with another 6 inches or so of seaweed, add a potato to be used during the bake as a test for doneness, and then sprinkle the whole business with 2 or 3 quarts of seawater. Immediately cover the pit with the wet tarp, weighing it down all along its edges with rocks. The clambake should steam for 45 minutes to an hour and the tarp should puff up soon after cooking begins, indicating that the hot rocks are producing steam. After 45 minutes carefully lift a corner of the tarp and test the potato. If it's done, the clambake is complete; if not, put back the tarp and let the pit steam for another 10 minutes or so.

Serve with beer, melted butter, and lots of paper towels. Watermelon and coffee can finish off the evening. ■

United States
Government Printing Office
Division of Public Documents
NOAA Magazine
Washington, D.C. 20402

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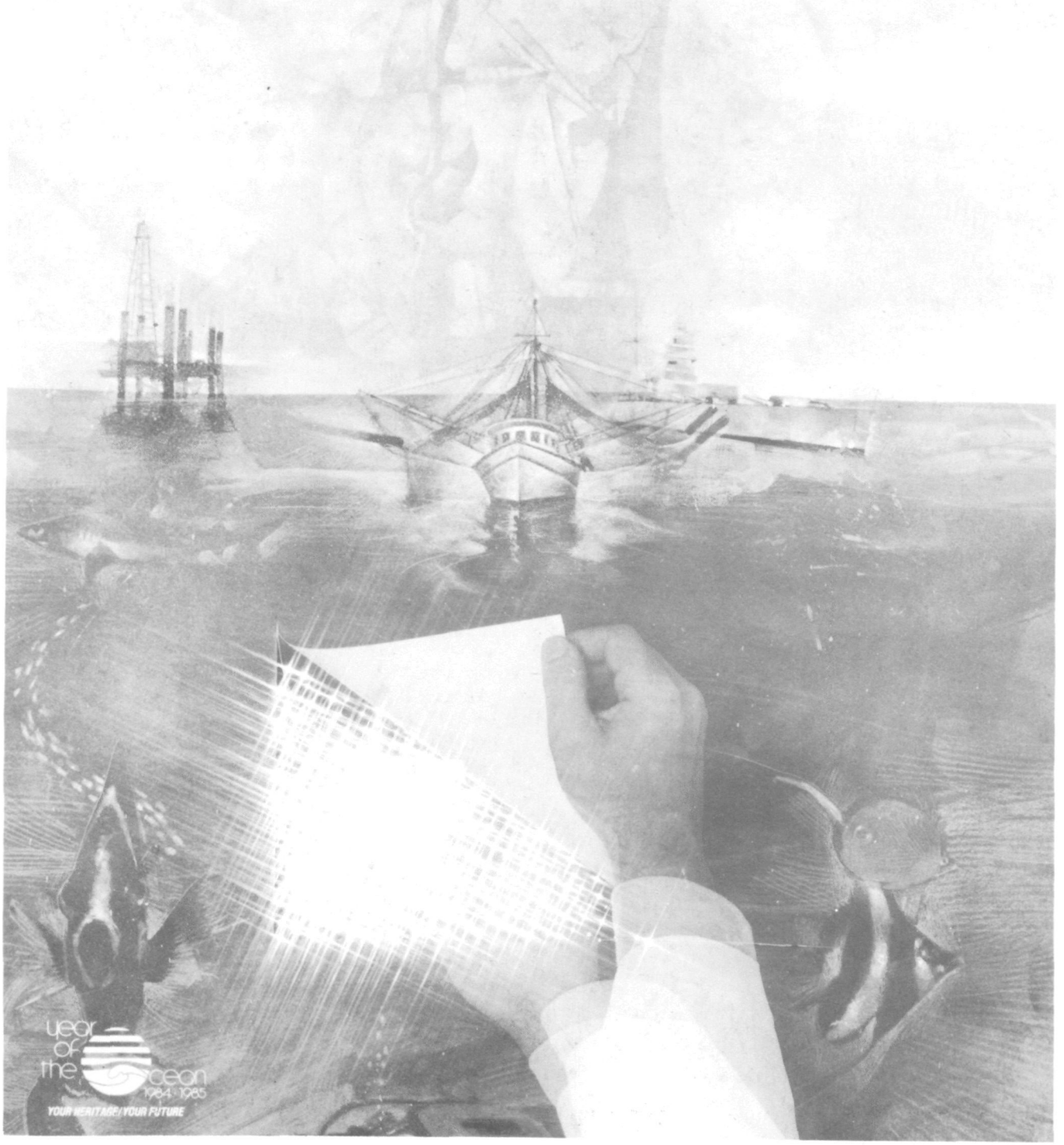
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