Volume 11 Number 4 Fall 1981

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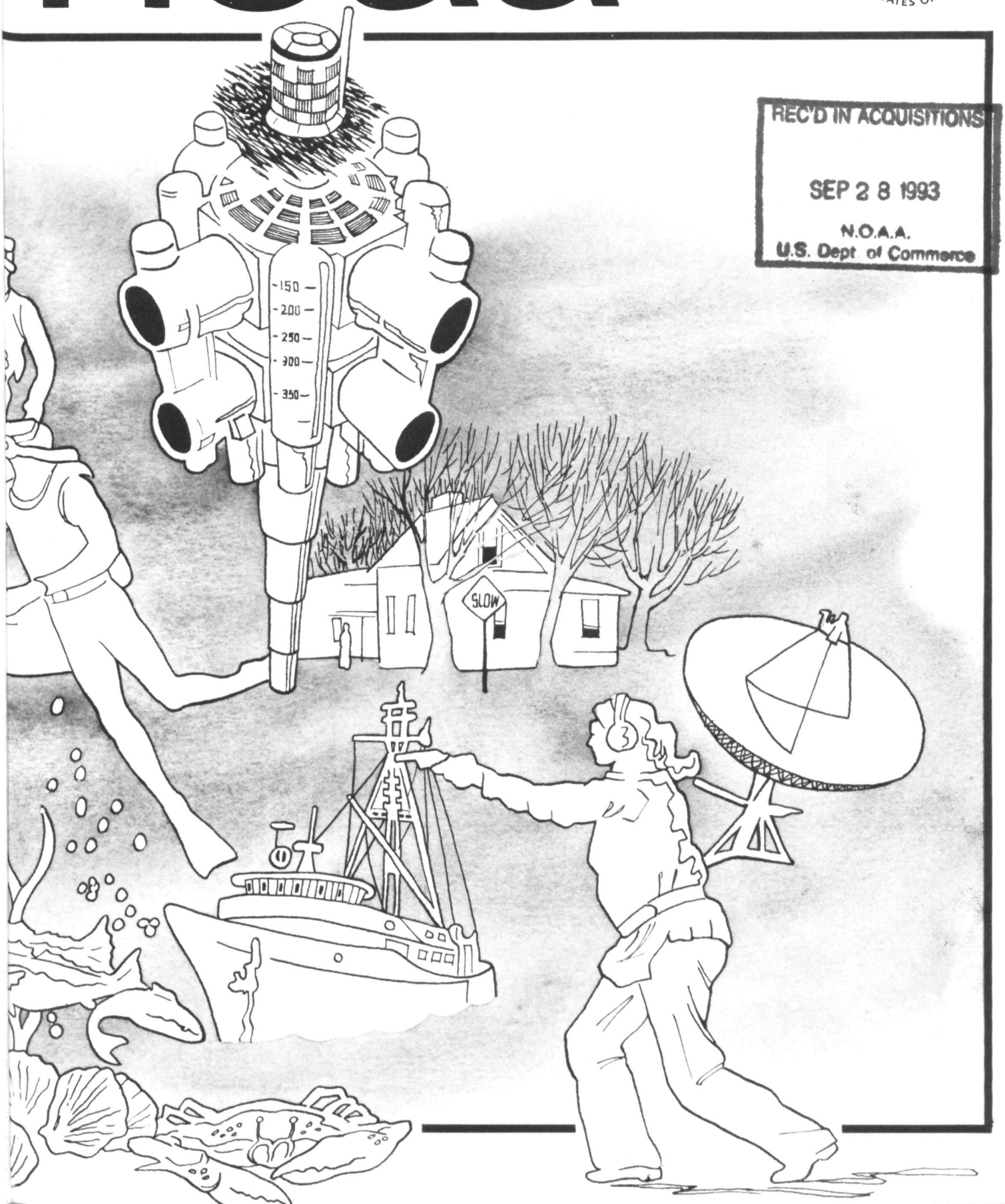

National Oceanic and Atmospheric Administration

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COVER
A potpourri of people, places, and activities illustrating NOAA's wide spectrum of interests.

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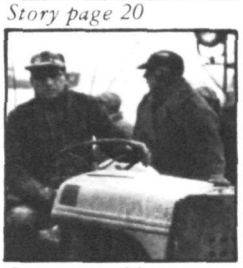
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U.S. DEPARTMENT OF COMMERCE
Malcolm Baldrige, Secretary

National Oceanic and Atmospheric Administration
Dr. John V. Byrne, Administrator

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OTEC: A Promising New Source of Energy

James Lawless

Acting Director, Office of Ocean Minerals and Energy

As we continue our search for new and cheaper sources of energy, our technology and imagination have taken us deeper and deeper into the earth's crust, both on land and at sea, in quest of coal, oil, and natural gas. This pursuit is likely to continue far into the future.

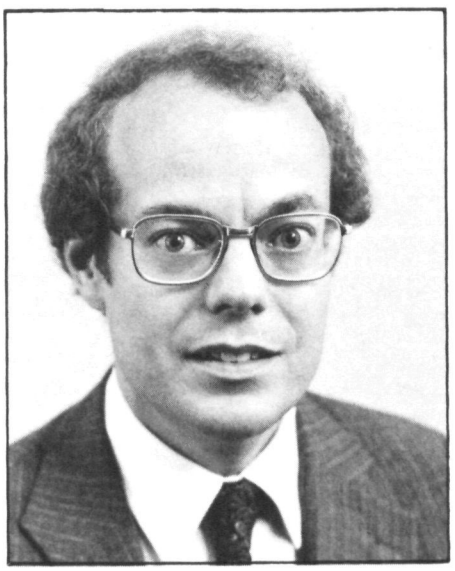
Yet one of the most remarkable—and as yet untapped—energy sources lies in the upper few hundred feet of thousands of square miles of the ocean lying off the shores of more than 60 nations. That energy, the solar heat stored in the surface waters of the world's tropical oceans, is the foundation for a technology called Ocean Thermal Energy Conversion, OTEC for short.

OTEC, which uses the temperature difference between the ocean's warm surface water and the cold water several thousand feet deep to drive an electric generating turbine, was first described theoretically 100 years ago. Dramatic changes in OTEC technology and in the cost and availability of fossil fuel have occurred since that time.

In addition, over the past several years, NOAA and the Department of Energy have been assisting private industry efforts to refine OTEC technology and prove its worth. We are now at a point where OTEC-generated electric power is no longer a distant dream. It is a very real possibility.

Last July, NOAA's Office of Ocean Minerals and Energy published regulations designed to clear the way for U.S. industry to become involved in this new technology. If private industry should decide that OTEC makes economic and technological sense—and we have every reason to believe it will—the benefits to the U.S. economy in the next 30 years could be enormous. Although it is unlikely that there will be any large OTEC power plants installed off the U.S. mainland in the immediate future, use of OTEC on U.S. islands and export of OTEC technology to only a small percentage of the countries where oceanic conditions make OTEC feasible could result in more than $200 billion in American business between now and the year 2010. The effect on the domestic economy—about 144,000 new jobs and $780 million in tax revenues annually—would be salutary indeed.

Last January, Secretary Malcolm Baldrige promised the Commerce Department would create a "business climate which allows the full potential of our economy to flourish," and referred to departmental programs that "can assist business...in expanding output, improving productivity, stimulating innovation, and creating new jobs." The climate NOAA has created for OTEC will help realize that goal. ■



Energy from the sea

OTEC: The Sleeping Giant

Brian Gorman

Mini-OTEC, an experimental Ocean Thermal Energy Conversion plant stationed off the shores of Hawaii, surprised nay-sayers by producing usable power without fouling.

Exactly one hundred years ago the brilliant French physician and physicist Arsene d'Arsonval published a short paper on a method for converting into electricity the heat stored in the warm surface waters of the tropical oceans. For the twenty-nine year old d'Arsonval and his colleagues at the College de France, the paper remained little more than an interesting examination of how energy could be transformed from one form to another. Neither the technology nor the need for such a system existed in the late 1800s.

Today the need for such alternative energy sources is unquestioned and the technology—under the name Ocean Thermal Energy Conversion or OTEC—has been developed to the point where Dr. John V. Byrne, Administrator of the National Oceanic and Atmospheric Administration, sees the possiblity of $200 billion in OTEC export business for the United States over the next three decades. New industry, based on OTEC technology, could create nearly 150 thousand new jobs generating millions in local, State, and Federal taxes annually according to one study, while another claims that development of even a small portion of the total OTEC economic pie would have a major effect on the Nation's employment and trade business.

Ironically, by the late 1920s, when d'Arsonval's countryman Georges Claude began to examine the practical applications of OTEC, the need for exotic sources of electricity was as uncompelling as it had been a half century before. Technological know-how had changed, however, and in 1930, with support from the French government, Claude set out to construct and install a small operating ocean thermal difference plant off Matanzas Bay, Cuba.

The plant, located on land, was to draw the relatively warm water of the bay and use its heat to evaporate seawater under a vacuum. The resulting steam would be used directly as a working fluid to drive a land-based, low pressure turbine. Cold water from the deep ocean, drawn through a pipe more than a mile long snaking its way offshore to a depth of about 2,000 feet, would cool the steam in the plant's condensors.

And so it did. But the plant, beset from the beginning with logistical manufacturing, and weather problems,

Ocean Thermal Energy Conversion

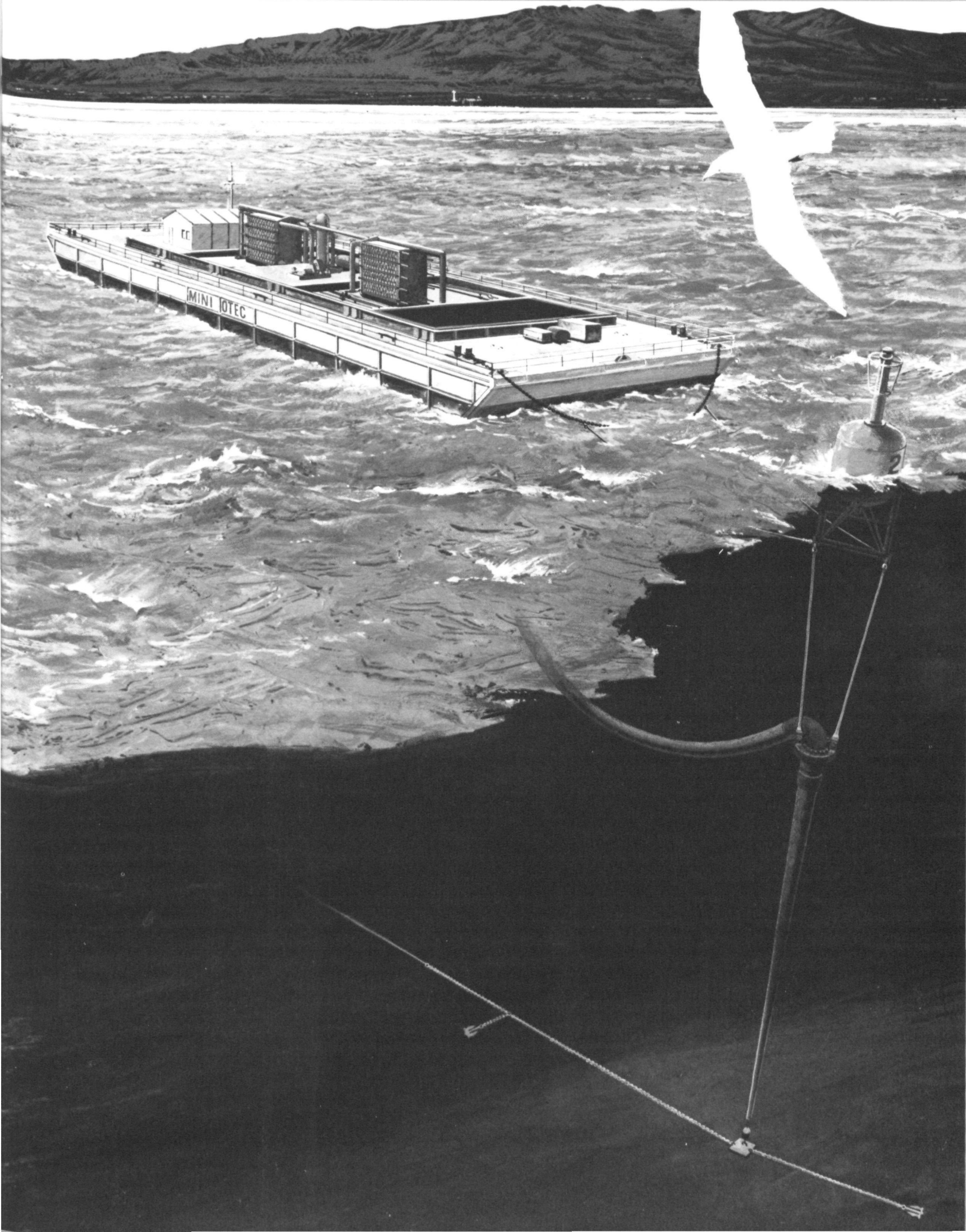
was less than a spectacular success. Although Claude did in fact manage to generate a small amount of power, the array of pumps to draw seawater and maintain the necessary vacuum in the system used more electricity than the plant produced. Two weeks after the first kilowatt of electric power was produced, a storm destroyed the world's first OTEC plant and with it a brilliant French engineer's hopes for producing electricity from solar energy stored in the ocean's surface.

The technology, however, had been developed and proven, and like some sleeping giant, seemed merely to be waiting the right moment when demand for electricity and the increasing economic and political cost of generating it by traditional means would shake it awake.

That time, according to many experts in the field, may very well be now. The explosion of world energy prices following the Arab oil embargo in 1974-75 has led to an increasing concern about not only the price of imported oil but its very availability at any cost. And this awareness is most acute in many island and coastal areas, both in Third World and industrialized countries, which, because of an ironic accident of geography, are at once heavily dependent on oil imports and prime sources of the oceanic conditions that make them ripe for OTEC. According to a Department of Energy study, more than 60 nations, lying roughly 20 degrees north and south of the equator, have off their coasts the 40 degree Farenheit temperature difference between cold deep water and warm surface water that could make OTEC economically feasible.

And the technology for OTEC itself has changed too. The relatively inefficient Claude plant was based on a so-called open cycle that used seawater as a working fluid. Most engineers feel that a closed system, using a working fluid like ammonia that boils and condenses over a small temperature range and contains no dissolved gases to complicate evaporation, may be more efficient.

But making OTEC work may not be as simple as it sounds. To generate a net output of about 400 megawatts, comparable to that kind of coal- or oil-fired plant that can provide power to about 60,000 American households, an OTEC plant would have to call on a mind boggling list of hardware, including: a cold-water intake pipe 100 feet in diameter and 3,000 feet long, 2.6 million gallons

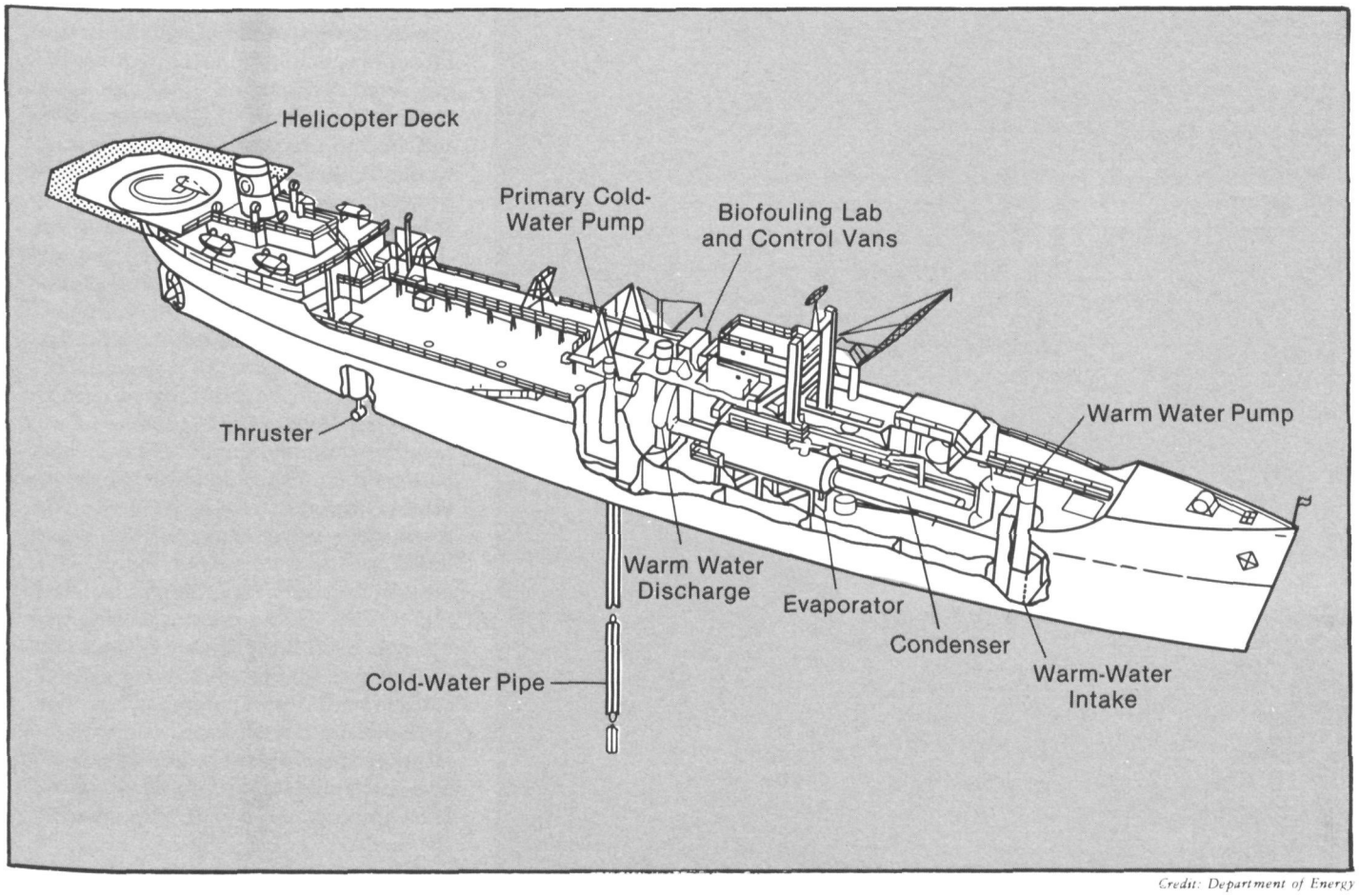

MINI OTEC

Credit: Department of Energy

The real thing and an isometric cutaway of the OTEC-1 test platform, a converted Navy T-2 tanker used by the Department of Energy to test OTEC components.

of ammonia or other suitable liquid as a working fluid, hundreds of miles of tubing in a heat exchanger that would be subject to the ravages of marine fouling and seawater corrosion for 25 years or more, and a continuous flow of water (for both heating and cooling) of 140,000 cubic feet a *second*. That's 20 percent of the average flow of the Mississippi River. Nevertheless, there are those in both government and private industry who think it can be done, both economically and technically. Optimism for OTEC was fueled in 1979 by a 3-month trial of a small, experimental floating OTEC plant off the coast of Hawaii. The $3 million project was financed by Lockheed in partnership with the Dillingham Corporation, Alfa-Level of Sweden (a leader in the manufacture of heat exchangers) and the state of Hawaii. It proved successful enough to prompt one industry spokesman, Malcom S. Jones, head of Reynolds Metals Company's energy conversion research division, to opine that the experimental plant had "opened up everything" for OTEC. Reynolds, and other companies that produce products like aluminum and ammonia that require vast amounts of energy to manufacture, are particularly interested in OTEC plants as possible floating factories.

Although only experimental, the mini-OTEC plant surprised a number of nay-sayers, according to R. R. Beall of Lockheed. "Contrary to the critics, the heat exchangers were not clogged by fouling from marine organisms. The cold water did not contain large



Credit: Department of Energy

amounts of dissolved gases to reduce the rate of heat transfer. We know that OTEC is technically feasible and we are convinced that it can be made economically competitive."

The engineering success of the plant, which produced its designed requirement of 50 kilowatts of electricity (40 kilowatts of which was consumed to operate the plant) during its 3-month sea trials, was in part responsible for convincing Congress to pass legislation in the summer of 1980 designed to give OTEC a major push toward commercialization. Included in the law's provisions was authority for a regulatory regime, administered by the National Oceanic and Atmospheric Administration's Office of Ocean Minerals and Energy, to ease the way for American firms to acquire licenses for OTEC plants and to develop OTEC technology for export.

The potential effect of the NOAA regulations, published last July, was signal enough to prompt NOAA Administrator Byrne to declare that they could clear the way for a $200 billion export business for the United States over the next 30 years.

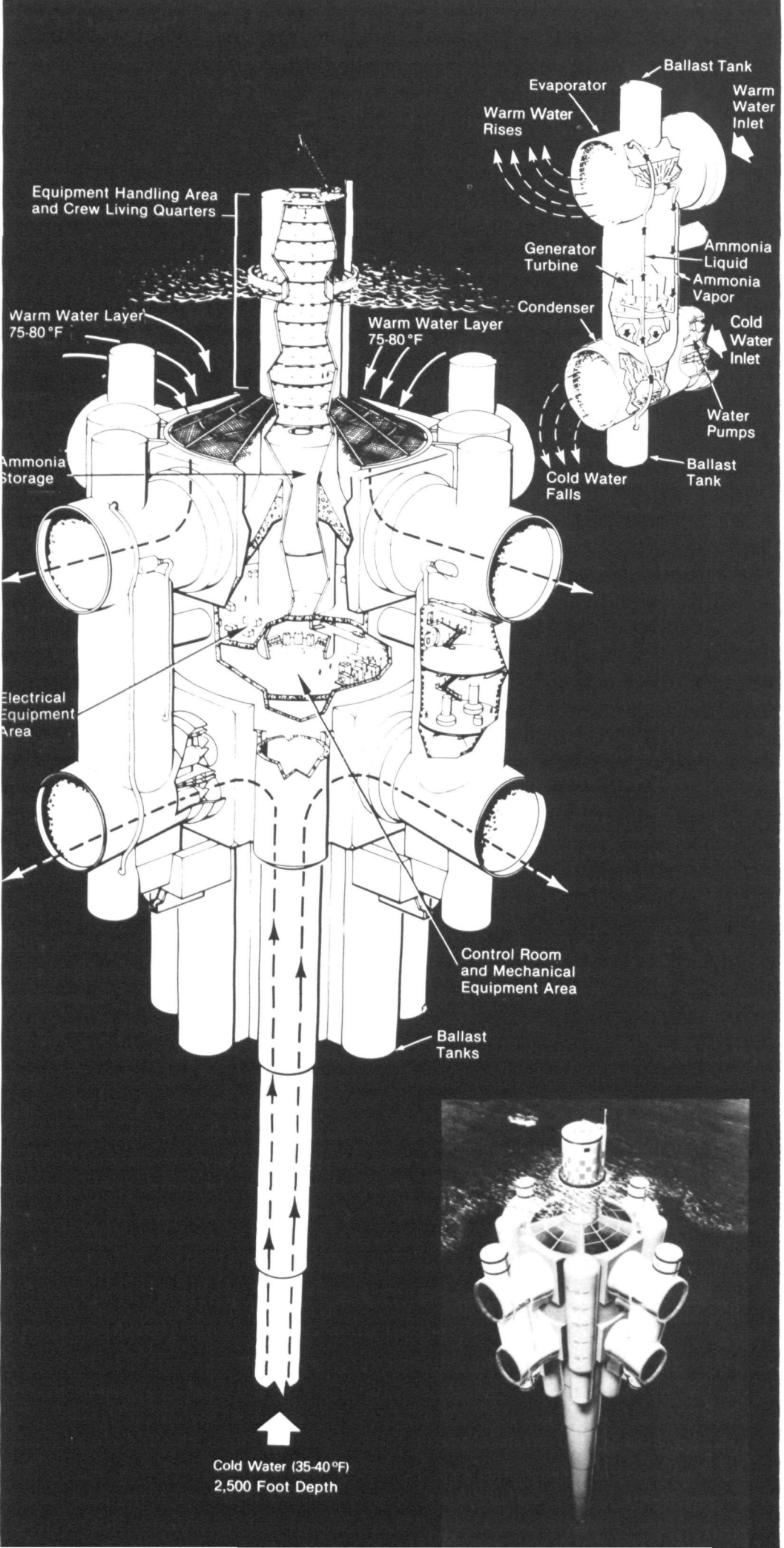
Although it is possible that there won't be any OTEC plants deployed to meet electric needs on the U.S. mainland, at least not in the near future, principally because the necessary seawater temperature differences aren't available very close to shore, the potential for exporting U.S. manufactured equipment is for some OTEC proponents a distinct possibility. At a recent meeting of a 4-day Energy Department conference on ocean thermal energy conversion, Sen. Charles McC. Mathias noted that platform construction, possibly for export, has a vast potential for coastal states with shipyards. He claimed a single contract per year could produce 12,000 permanent jobs for a shipyard.

Recent Department of Energy evaluations suggest that the projected costs of OTEC-generated electric power may make it competitive with fossil fuel power on U.S. islands and other island or coastal nations. Based on current economic analyses and projected market conditions, the Energy Department predicts that island baseload electricity will cost between 130 and 230 mills—13 to 23 cents—per kilowatt hour (in 1980 dollars) by 1995. Present OTEC technology, according to the study, can generate electricity at a cost of about 100 mills per kilowatt hour.

The Japanese, in fact, already have a small OTEC plant under construction. The plant, to be operated by Kyushu Electric Power Co., will be located near Okinawa and will use the warm water discharge from a nearby oil-fired plant as its source of heated water. It is designed to have a net output of about 50 kilowatts. According to Nipon Keizai Shimbum (Japan Economics Journal), Kyushu Electric envisions ultimate development of a much larger power plant of several thousand kilowatts output if the test plant works as planned.

Japan, like many island nations, is plagued both by high imported oil costs and the added expense of providing service to remote island communities. Kyushu, for example, provides electric power to 30 separate islands with 170 oil-fired plants at double the already high cost of services on the main islands.

An economic study conducted by Dr. James L. Roney, president of Princeton Energy and Environmental Research Company also predicts an economically optimistic picture for U.S. export of OTEC equipment. According to



Roney's study, "Employment and Economic Impacts of OTEC Commercialization," construction of nine 400 megawatt plants "on line" by about 1997, with another 22 plants on order and in various stages of manufacture, would result in employment of about 144,000 workers, 60,000 of them at shipyards or other OTEC construction sites. This activity would add $11.4 billion to the country's gross national product and generate some $180 million in State and local taxes and $600 million in Federal income taxes annually.

A NOAA analysis of the new regulations governing OTEC development says the potential export for the U.S.-built plants "can only be described as vast." Approximately 70 countries and territories—many of them lesser developed and now dependent of imported oil—are located within 200 miles of usable OTEC resources, according to NOAA. Even if the United States could capture only 10 percent of this market, a conservative figure, exports between 1990 and 2010 would amount to a capital investment on the order of $170 billion and would have a "major effect" on U.S. employment and trade balances, the analysis claims.

Although the first commercial use of OTEC power is expected to be for generating electricity that would be fed into an already existing electric grid for domestic and industrial consumption, an exciting aspect of OTEC has intrigued engineers and economists: the production of products like ammonia that consume vast amounts of natural gas. Ammonia is the principal source of nitrogen for commercial fertilizer. Currently, enormous quantities of natural

A gigantic heat engine—such as this OTEC plant based on a Lockheed Missiles and Space Co. concept—uses the warm surface water as the heat source, and cold water from the depths as a heat sink. The warm water vaporizes a liquid, such as ammonia. Like steam, this gaseous, pressurized ammonia drives turbine-generators. The ammonia then is condensed to its liquid form by the cold ocean water, and this closed cycle continues. For scale, note the size of the human figures in the control room at center.

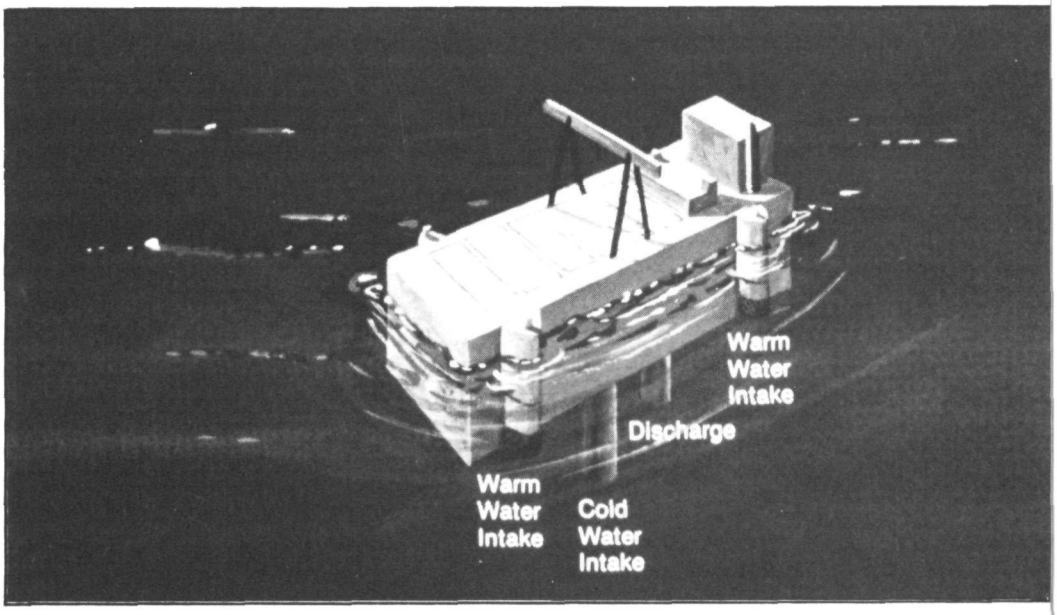
gas are used both as a source of heat for processing the ammonia and as a source of raw material. In 1978, about 3 percent of the natural gas produced in the United States—equal to the total domestic consumption of natural gas in California that year—went into making ammonia. OTEC plants, producing hydrogen by electrolysis from seawater and extracting nitrogen from the air, could, according to some projections, conserve the equivalent of 300,000 to 500,000 barrels of oil a day.

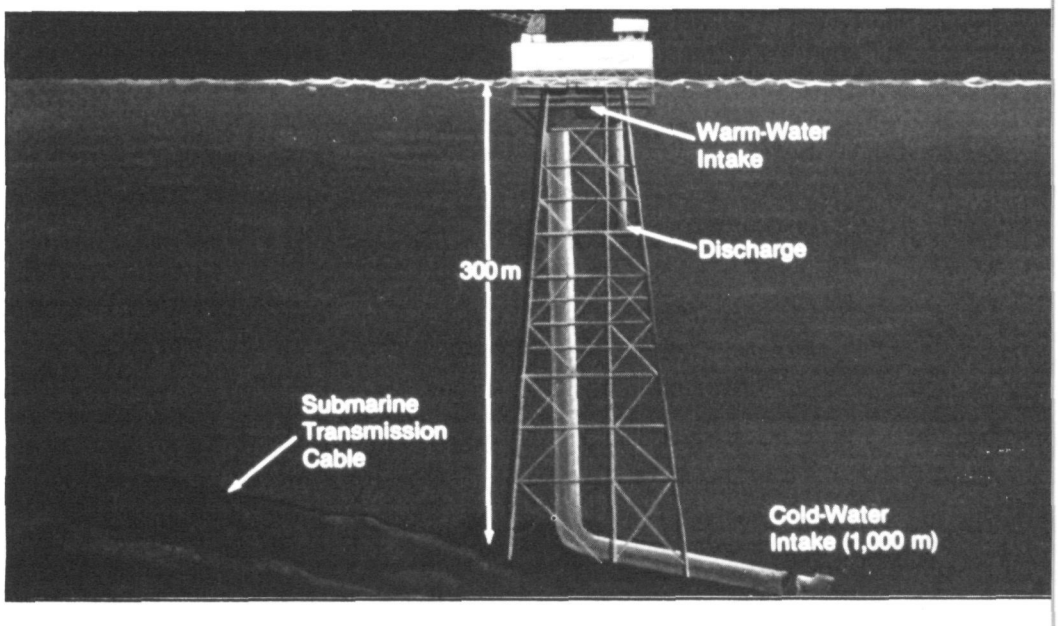
Although the future of OTEC will depend on the business community's making a long-term capital commitment to OTEC, things are already looking up. Richard Norling, head of NOAA's OTEC office says he expects two or three companies, one of them on the U.S. island territory of Guam, to apply for preliminary licenses some time next year.

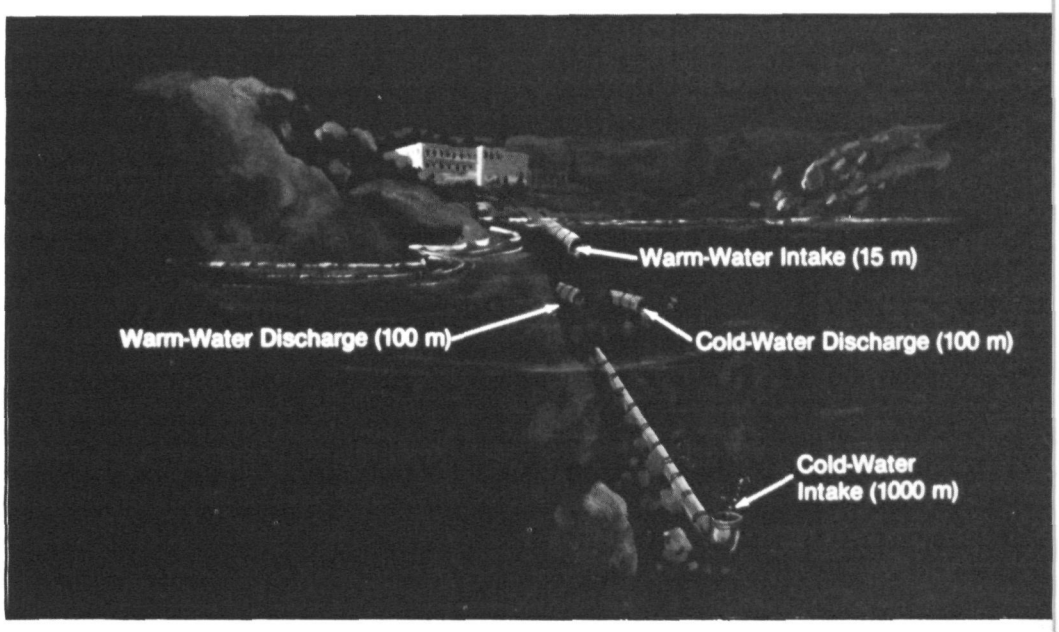
The quickening of OTEC activity today may indeed herald the awakening of a sleeping giant—a billion dollar industry growing out of George Claude's dream—prematurely built and prematurely shattered on the shores of Cuba 50 years ago. ■

A 400 megawatt OTEC facility could:

- produce enough power for about 60,000 households, saving 2 million tons of coal or 6 million barrels of oil per year;
- produce about 300,000 metric tons of aluminum a year from alumina (U.S. demand for aluminum in 1981 is expected to be about 5 million metric tons);
- produce about 410,000 metric tons of ammonia a year (U.S. projected demand for ammonia in 1981 is about 19 million metric tons);







These three conceptual drawings show possible OTEC plant configurations—ship mounted, shelf mounted, and landbased. NOAA's Office of Ocean Minerals and Energy is easing the way for American firms to acquire licenses for OTEC plants and to develop OTEC technology for export. OTEC-connected exports could bring the Nation $200 billion over the next 30 years.

Pennsylvania, Virginia, West Virginia, and Kentucky are involved in the Appalachian flood warning system. Circled are the 12 adjacent counties containing some of the Nation's most flood-prone valleys. Two counties in Pennsylvania are also in the prototype system.

Flood Warnings: The Gift Of Time

Don Witten

"There is a nightmare quality to a flood: the inexorable rise of water, feelings of absolute helplessness inspired by the incalculable force of the crest of water which drives ahead of it everything but the bedrock. It overruns, drowns, and pulverizes everything that does not or cannot move quickly enough."

This is the statement of survivor Bill Gilbert, writing about the 1977 Johnstown, Pa., flood in *Audubon* magazine.

Some 76 other people knew the terror Gilbert described but never lived to tell about it. The disasterous flood that struck Johnstown on July 19-20 caused their deaths and more than $200 million in property damage, when up to 12 inches of rain fell on the seven-county area in 9 hours during a violent storm.

According to Dr. Richard E. Hallgren, Director of NOAA's National Weather Service, "flash floods now rank as one of the major killers and destoyers among weather-related disasters in the United States. Since 1968, the average annual death toll from flash floods has risen to about 200 Americans—more than double the rate of the 1960's and triple that of the 1940's. Flood-related damage in this country now amounts to about $2 billion a year."

Because of the Johnstown flood and numerous others like it, NOAA initiated a National Prototype Flash Flood Program in 1978.

This program is part of a major thrust to solve the Nation's flash flood problem through cooperative efforts involving Federal, State, and local governments.

The goal of the Flash Flood Program, Dr. Hallgren said, is to provide reliable warnings of local flooding from 30 minutes to 3 hours or more in advance of high water in the country's high-risk flash flood areas.

"This level of warnings, combined with effective local action plans, is expected to reduce substantially the loss of life and property," he added.

As a first step in carrying out the National Flood Warning Program, NOAA's National Weather Service is working with the Appalachian Regional Commission (ARC) and four central Appalachian states to develop a prototype system covering some of the most flood-prone valleys in the Nation. Additional funding is being provided by the Tennessee Valley Authority.

The Appalachian warning system covers 12 adjacent counties at the intersection of Kentucky, West Virginia, and Virginia, and two counties in Pennsylvania. It will be expanded during the next two years to cover 80 counties in the same central Appalachian area. Ultimately, the expanded system will be evaluated for application in other, high-risk flood areas of the Nation.

According to Robert L. Carnahan, Chief of the Warnings Coordination Staff at NWS, "the Appalachian System combines the best in existing, local volunteer observer network with radio-reporting raingages in remote area and automated river level sensors.

"Improved communication networks in the warning area and mini-computers at the county and State level provide for the quick assimilation and analysis of the reported flood information," he said.

John Monro, project coordinator of the Warnings Coordinator Staff Office, said that the Appalachians were selected as the initial site for development and testing of the prototype warning system for good reason:

"Total flood losses in the 80 Appalachian counties to be covered by the warnings system are estimated to be over $3.5 billion during the 10 years through 1977."

Another key factor, Monro said, was the willingness of the State and county governments involved to share responsibility for maintenance and operation of the warning system equipment.

"Not only will the new system save lives in the 80 counties, but we estimate that $35 million in flood losses can be saved there each year."

Costs for the warning system covering the 80 counties will amount to an estimated $4.5 million. This includes total cost of equipment design, procurement, and installation.

Even as the National Flood Warning Program was being formulated, NOAA was taking steps to help solve the critical flood problem in the central Appalachians. New radars were installed at Weather Service offices at Jackson, Ky., and Beckley, W. Va., to maintain close surveillance over storms in that area.

The National Weather Service also has improved its national flood forecasting capabilities, which will provide immediate benefits to the Appalachians. A new unit created at the National Meteorological Center in Camp Springs, Md., is allowing Weather Service meteorologists to monitor the Nation for weather systems capable of producing flash-flood rainfall within the upcoming 12-24 hours.

"The process of shoring up our defenses against weather disasters is a long and continuing one. Improved capability for detecting severe weather is critical to issuing public warnings about fast-moving, destructive storms," said Dr. Hallgren.

"The flash flood warning system in central Appalachian will extend the umbrella of protection across an area where flash floods are a way of life. Its installation and maintenance require significant expenditures of effort and money," he said.

"But," he added, "we will find it is indeed a small price to pay for a warning capability so necessary to protect the lives and property of the many citizens living in the Appalachian areas." ■

Credit: American Red Cross

Flood-Prone Danger Spots

The increase in deaths and destruction from flash floods results partly from the spread of urban development and partly from increased population mobility. In cities, removal of vegetation increases the flow rates of small streams. Bridges, culverts, and buildings are often constructed in a manner that impedes the flow of water. In the countryside, increased use of mountainous areas and narrow canyons for recreation is exposing growing numbers of unwary visitors to flash floods. The list of danger spots is growing. By latest count, more than 15,000 U.S. communities and recreational areas were identified by the Flood Insurance Administration as flash flood prone and are spread through all but a few of the Nation's 3,143 counties. Some 3,000 of these flood-prone areas are high risk in terms of potential deaths and property damage.

These scenes from seven of the most tragic floods over the past 12 years highlight the need for an improved national Flood Forecast and Warning Program.

Credit: Richmond Times-Dispatch

***August** 1969, James River Basin, Va.—153 dead and millions of dollars in property damage as dying Hurricane Camille dumped more than 30 inches of rain in less than 8 hours.*

Credit: U.S. Coast Guard

***June** 1972, northeastern United States—120 killed and more than $2 billion in property damage as the remnants of Hurricane Agnes produced widespread and destructive flooding and flash flooding in Virginia, West Virginia, Maryland, Pennsylvania, and New York. This is the Susquehanna River at Wilkes-Barre, Pa.*

Credit: American Red Cross

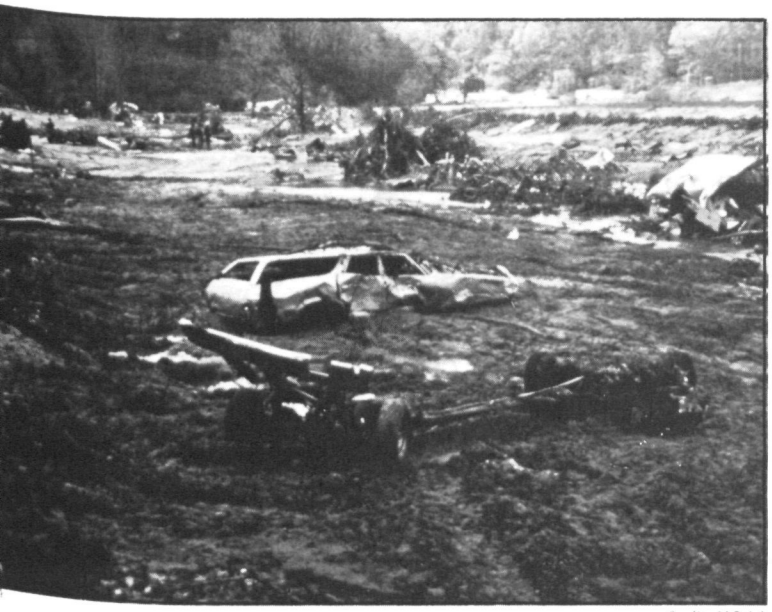
***June** 1976, Big Thompson Canyon, Colo.—139 drowned and millions in property damage after a thunderstorm deluged the western third of the canyon with 12 inches of rain in less than 3 hours.*

Credit: American Red Cross

***February** 1972, Buffalo Creek, W. Va.—118 killed and hundreds of homes washed away as a dam made of coal mine waste gave way after heavy rains.*

Credit: NOAA

***June** 1972, Rapid City, S. Dak.—236 dead and $100 million in property damage after a large, slow-moving thunderstorm unleashed torrents of rain on the slopes of the Black Hills.*

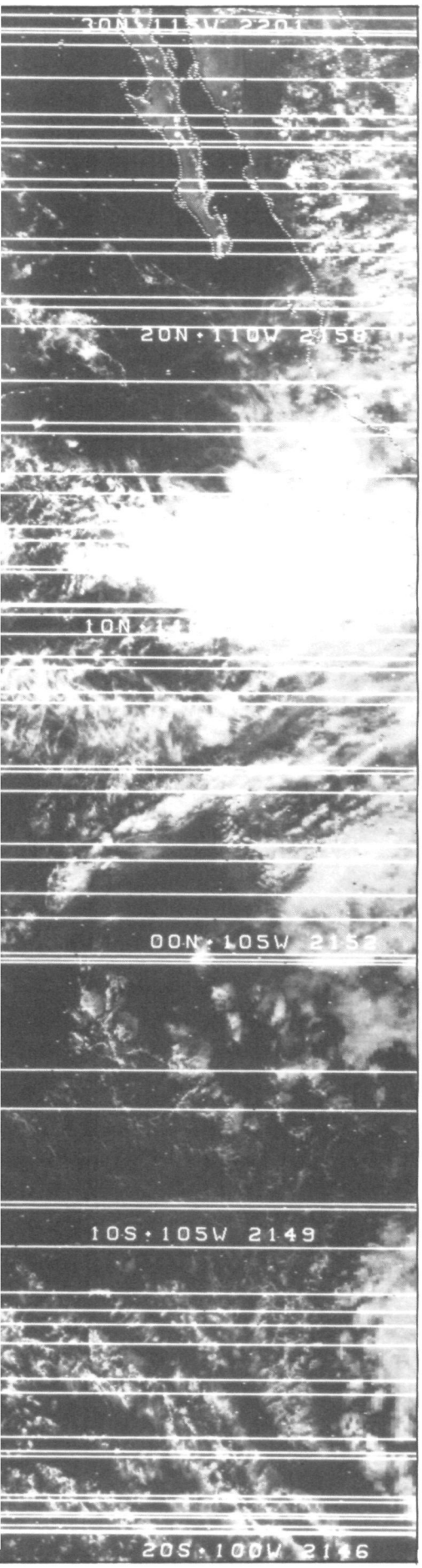


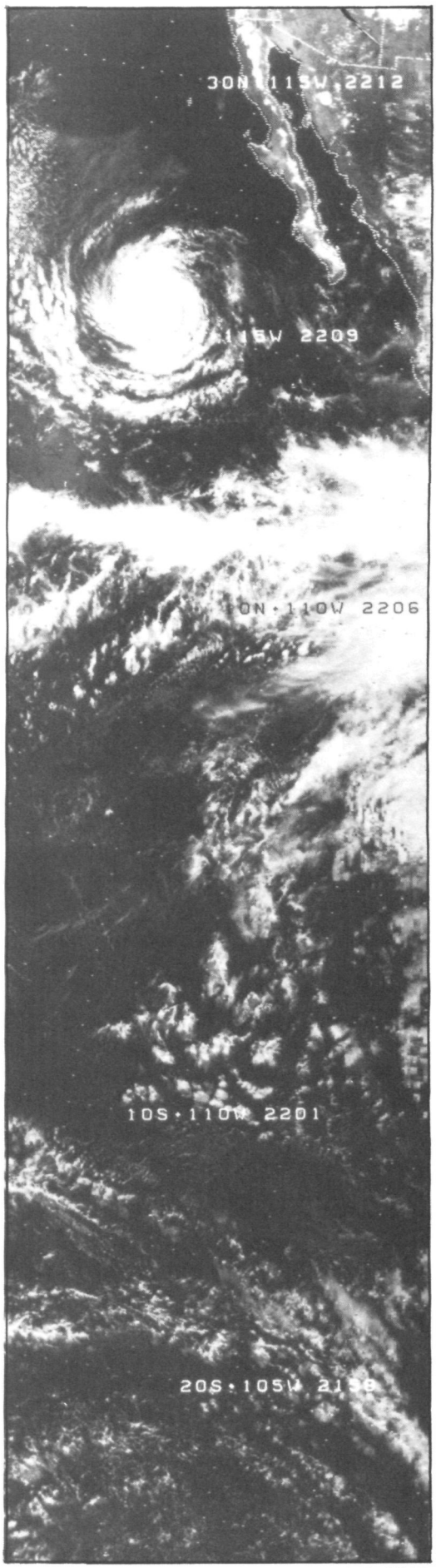
Credit: NOAA

***November** 1977, Taccoa, Ga.—40 dead, half of them children, when heavy rains ruptured an earthen dam and demolished a mobile home community in the valley below.*

Credit: American Red Cross

***August** 1978, Texas hill country—33 dead and near 100 million in damage where over 30 inches of rain fell in 36 hours with a 12 hours total of 28 inches. This was near San Antonio.*





Credit: NOAA

Craft masters whose only tools are their imaginations and computers, are repairing malfunctioning satellites as far as 22,300 miles out in space; saving American taxpayers millions of dollars yearly while assuring weather forecasters and other meteorological users a steady flow of vital information.

Almost on a routine basis, these space age specialists with NOAA's National Earth Satellite Service diagnose ailments in spacecraft they've never seen, in some instances bringing the satellites back to life, and often correcting instruments which have been providing erratic readings.

Thomas J. Karras, Manager of the NESS Satellite Operations Control Center, (SOCC) leads a team of specialists whose knowledge of the intricate circuitry of NOAA's satellites and ground systems, and ability to manipulate these circuitry and systems, have extended the working lives of many of the spacecraft.

From control consoles at the operations center in Suitland, Md., Karras' team of engineers, satellite controllers, technicians, and other specialists operate and monitor not only the two operational GOES (Geostationary Operational Environmental Satellites) spacecraft and the operational NOAA-6 and NOAA-7 TIROS polar-orbiters, but also the four additional GOES satellites which, with partly-failed systems, are on "stand-by" status.

These spacecraft, costing upwards of $15 million each, are horrendously complex. So elaborate is their electronic instrumentation that in monitoring a single satellite's status literally thousands of points of information must be examined periodically by the control center.

This, of course, is done automatically by computer programs prepared long

Prognosis: healthy savings

before the spacecraft is launched. Computers also scan the responses to the queries radioed across space, automatically alerting SOCC personnel when the replies fail to match predetermined response patterns.

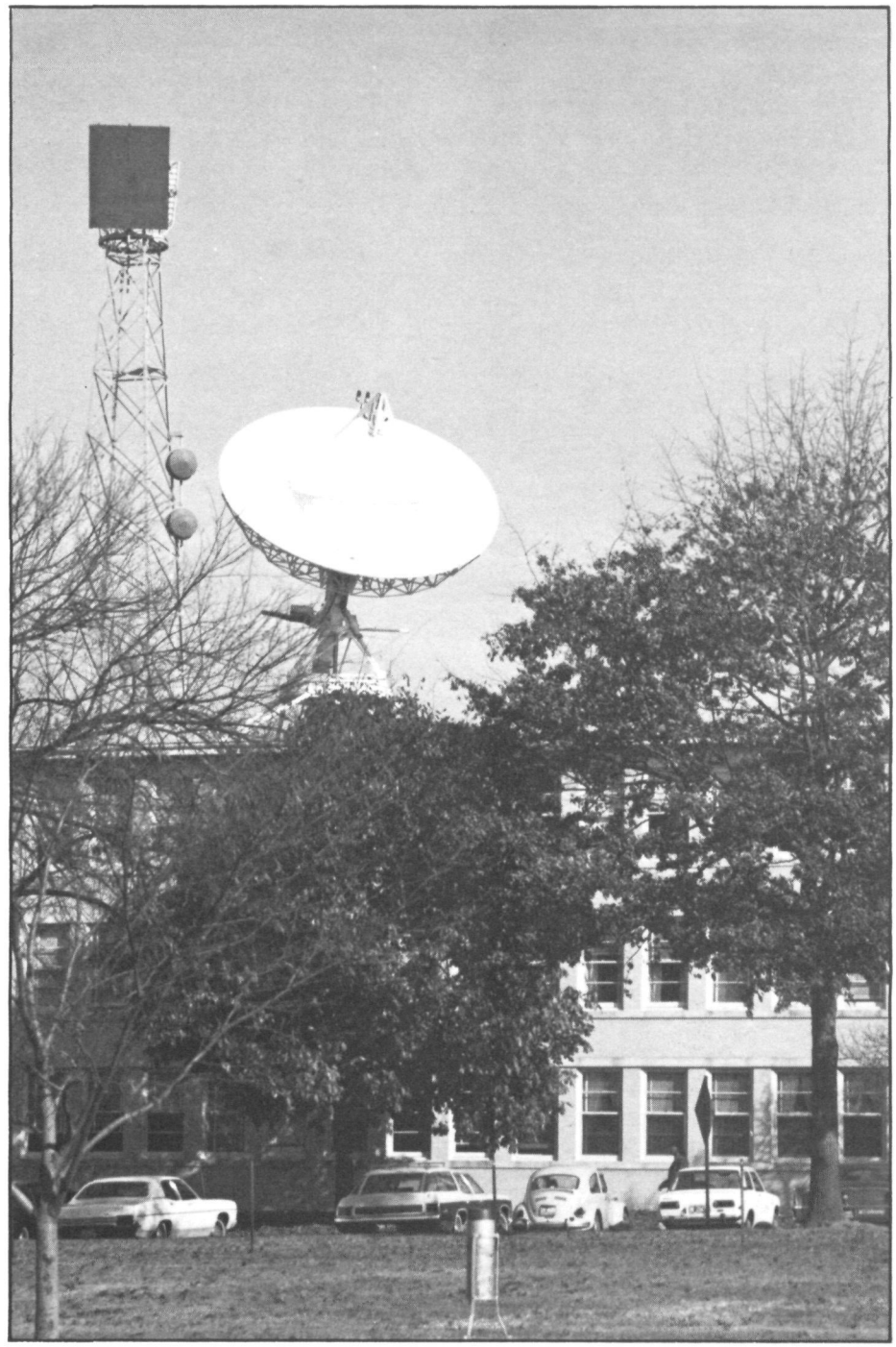
"The status reported by each of these thousands of information points tells us the health of the spacecraft," Karras says. "It's almost as if we were doing a daily EKG on each one.

"When we get an abnormal report from just one component in one of the satellites, we know something's going on that shouldn't be. It's then our job to find out what, and correct it."

To diagnose the problem, Karras and his team turn to reams of circuitry dia-

Checking vital signs from 22,300 miles

grams, command procedures, and pages of computer printouts, identifying first the component reported as abnormal, and then other components related to it. Each is queried again through the computer, using binary format language, or

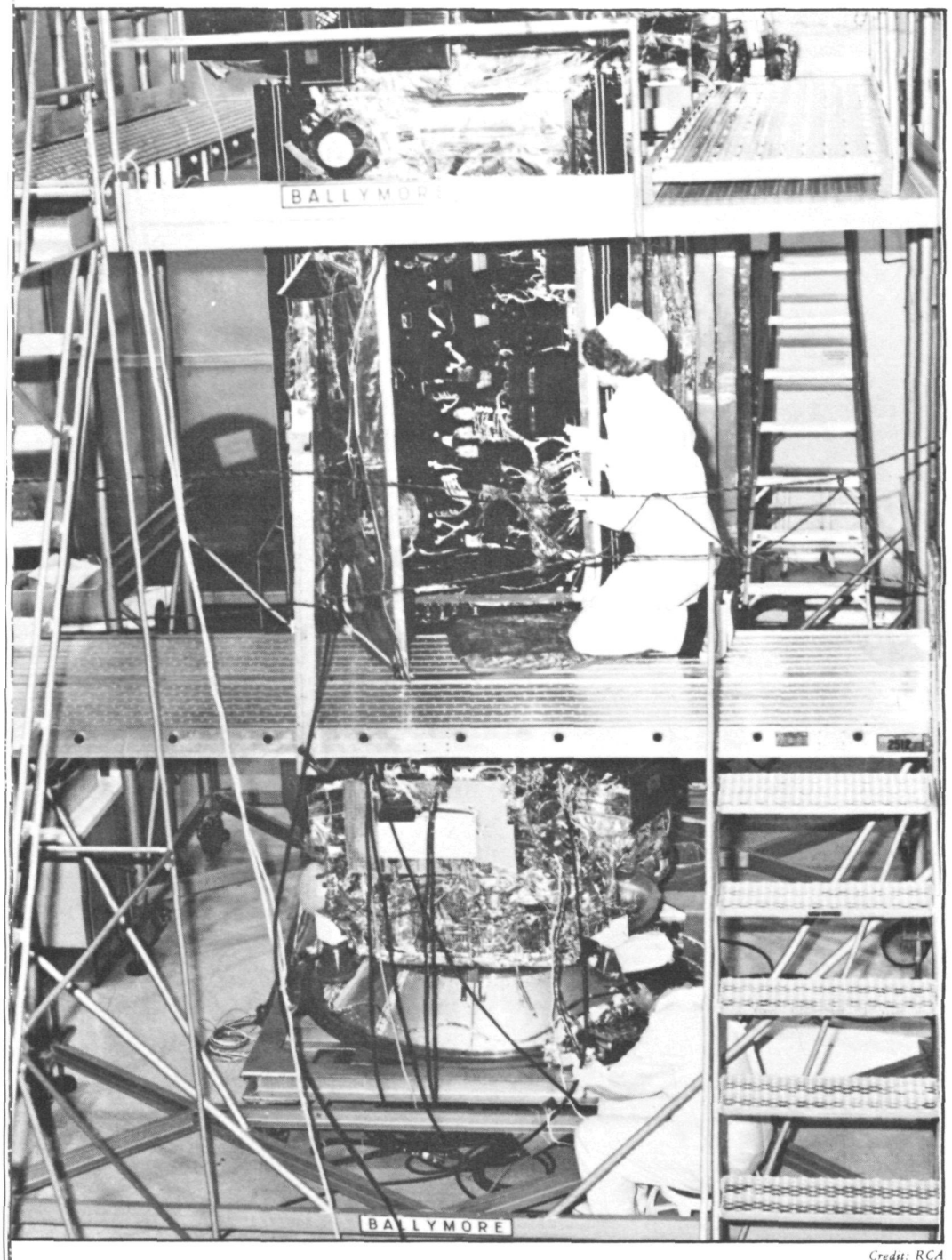


Credit: NOAA

Something's obviously wrong with the satellite image at the far left. In the image beside it, the horizontal bands have been eliminated by commands issued by engineers at the National Earth Satellite Service (right).

Rx For Ailing Satellites

William J. Brennan



Credit: RCA

Some of the complex circuitry of a NOAA polar orbiting satellite is revealed in this photo. After launch, all tests must be done remotely.

extensions of binary, octal and hexadecimal characters; each a stream of '1' and '0' bits of information which, to one familiar with computer language makes a readable message but to anyone else appears as an incomprehensible jumble of symbols.

Occasionally the apparent malfunctioning component is found to be operating properly, but being fed misinformation by a related element. Other times, the component itself is faulty. In any case, it is up to Karras and his associates to attempt to correct the problem with push-button surgery. If they fail, the usefulness of the satellite is diminished.

"Under normal circumstances," Karras says as an example, "when repair of an electronic circuit in a ground system is required, you pull the board and replace the entire circuit. But we're not operating in a normal situation. The circuit we have to repair is out of sight, hundreds of miles away, and there's no way to lay hands on it. We have to find another way to make repairs, at least until the Space Shuttle becomes available for retrieving satellites with major problems."

This is where the imagination and creativity of the NESS team—assisted by NASA and spacecraft contractors—is stretched to the limit; rerouting electrical signals so as to by-pass the failed component without degrading too much the information being transmitted. This sometimes involves a trade-off; accepting fewer or less detailed reports from elements of one system to assure adequate information from that with the faulty component.

Sometimes, too, in spite of its best efforts, the Karras team is unable to make corrections, in which case the faulty system is shut down and its back-up system activated. Each major system on NOAA satellites has a duplicate, for just such situations.

On occasion, tests are conducted at spacecraft contractors' facilities on satellites yet to be launched in an effort to duplicate the actual in-orbit failure or anomaly. Karras and his team have spacecraft simulators and emulators for use in attempting to reconstruct system failures or anomalies, to verify new command procedures, and for preparing and verifying software changes in on-board computers to fix or work around components or subsystem failures.

Most premature failures during the 16 years NOAA has had operational control of satellites have been minor in nature, Karras said, noting that each spacecraft has a life-span designed into it. GOES satellites now are designed to function fully for 7 years, while the average design life of the polar-orbiting satellites is 20 months. Longer life spans could be built into a spacecraft, Karras theorized, but the cost of the additional months or years of operation would be prohibitive, and it is less costly to accept a shorter life span and to replace the satellite with a new one which often carries improved instruments providing better or additional data.

What causes systems on spacecraft to fail before reaching the end of their design life? Sometimes it could be something as seemingly insignificant as a speck of dust which somehow eluded the "clean room" precautions under which all satellites are manufactured.

Other times it could be a short circuit caused by an unexplained power surge. Often, failures occur perhaps because of the stresses imposed upon spacecraft and their systems by the very nature of outer space; the alternating high and low temperatures as the satellite travels in and out of the shadow of the earth, radiation affecting microchips in instruments and on-board computers, and lubricant problems developing.

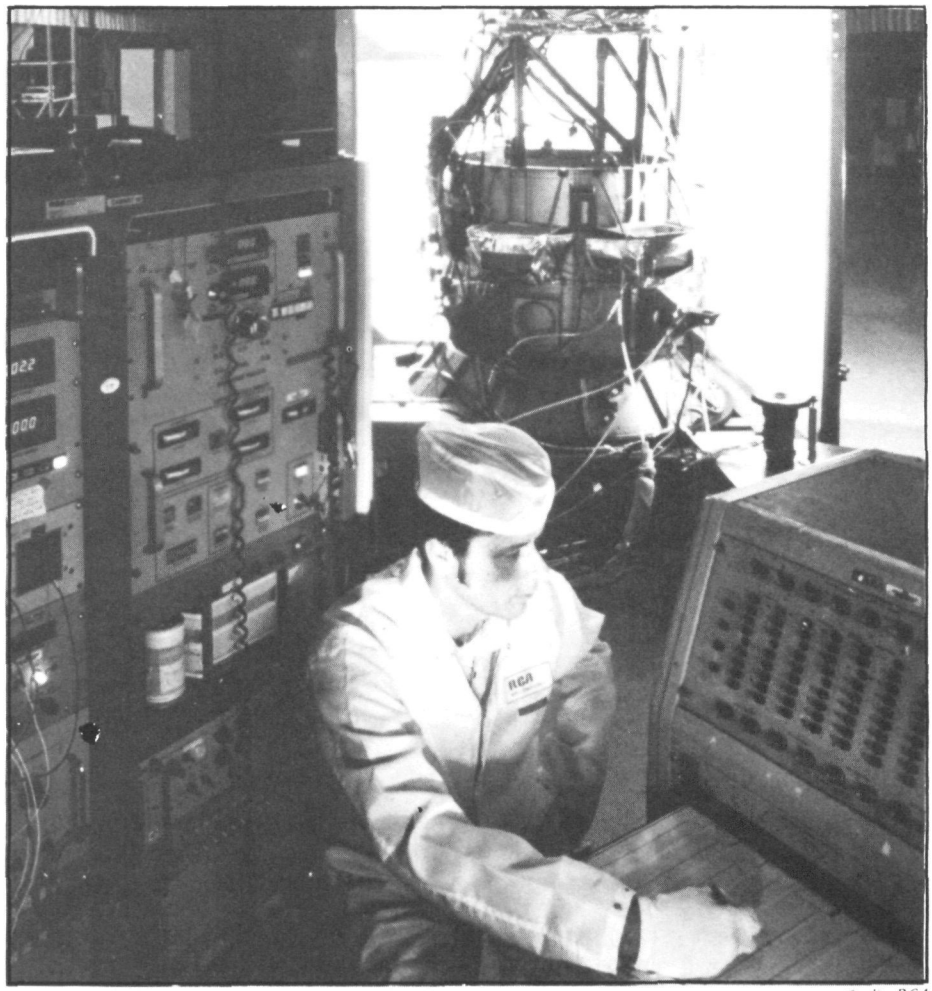
"One of the frustrations of this business," Karras says, "is that much of the time we don't know why a system failed, only that it did. Space, basically, is a very hostile environment, not only for humans but for equipment as well."

Only rarely do all systems on satellites fail at the same time. If they did, NOAA would have required many more than the 28 satellites it has managed since TIROS-10 became the agency's first operational spacecraft in 1965.

But it is not uncommon for a major system, and then its back-up, to cease operating while the remaining systems continue to function. The present GOES satellites have five primary systems; one providing visible and infrared imagery and sounding data, a second making solar observations, a third relaying information collected by data platforms at various locations on and above the earth's surface, a fourth transmitting a variety of weather-related information from the National Earth Satellite Service and the National Meteorological Center to earth stations elsewhere in the Western Hemisphere, and lastly a system for commanding the spacecraft and transmitting solar observation data.

The polar-orbiting NOAA-6 and NOAA-7 satellites also have five major systems, for imaging, obtaining soundings, measuring solar x-rays and energetic particles, relaying information from data platforms and determining the platform locations, and for commanding and controlling the satellites. Additionally, they have 10 tape recorders for acquiring global data and partial high-resolution data.

While separate control consoles are necessary for the GOES and the polar-orbiting systems in Satellite Operations Control Center, by and large they operate in much the same manner; computerized messages radioed in a variety of frequencies to the spacecraft, issuing commands, requesting information, and the like. On predetermined schedules, minor adjustments must be made to the GOES spacecrafts' orbits and attitudes, keeping them in their assigned locations and their instruments pointed properly. With NOAA-6 and 7, about 10 minutes of every hour is used for similar "housekeeping" chores.



Credit: RCA

In spite of ultra-clean conditions—note the technician's special clothing—a speck of dust may drift in and cause a satellite failure.

At the GOES console, operators are concerned not only with the fully-operational GOES East and GOES West satellites (GOES-5 and 4, respectively), but also with GOES Central—the partially failed GOES-2 satellite now used as a NOAA communications spacecraft—and three other geostationary satellites with various failed systems; SMS-2 and GOES-1 and 2. The last three are on "standy-by" status, ready to supplement the operational satellites in the event of partial failure.

"On occasion," Karras explains, "we have used two satellites, each with one or two unusable systems, to do the job a fully-operational spacecraft could do alone if it were available, while waiting for a new GOES to be launched, or during the transition phase of satellite maneuvers. If we have all of the systems necessary, between the two stand-bys, we can patch them together by scheduling and reconfiguring ground station antenna and computers to meet the mission requirements.

"Occasionally, when a component in the spacecraft computer fails or is intermittently operating, a software program is developed and loaded into the spacecraft to work around the faulty area to 'fake out' the computer system in order to keep the system running.

"But," he grins, "it makes life much more pleasant to have one satellite doing everything it should, all by itself. We have enough to do, riding herd on four perfectly healthy satellites.

"On the other hand, though," Karras says, "it is always a challenge to respond quickly to satellite malfunctions, saving a mission, and keeping products going to the users. It's a little like doing open heart surgery on a patient who's in outer space while the doctor and his team are on earth." ■

VIEW FROM SPACE

NOAA'S GOES-5 UP AND AWAY

NOAA's newest geostationary satellite, GOES-5, thundered into a cloudless evening sky at Kennedy Space Center in Florida on May 22 atop a Delta launch vehicle—the first ever to display the NOAA emblem. After two and a half months of use by NASA, the spacecraft became operational as GOES-East on August 5, replacing the ailing SMS-2, the oldest NOAA geostationary satellite still active. It was launched February 6, 1975.

The satellite's first operational image, taken from a lofty perch over the nation of Colombia, showed an almost cloud-free United States, but bad weather on its way eastward from the Pacific Ocean.

NASA used GOES-5 to conduct research with its VAS instrument, a new sensor which provides not only imagery, but also temperature and moisture measurements—data of great importance to weather forecasters.

Credit: NOAA

Credit: NASA

NOAA

The National Marine Fisheries Service's Suzanne Montero takes to the air aboard a U.S. Coast Guard helicopter on patrol in the Gulf of Mexico.

Credit: NOAA

NOAA profile

Suzanne Montero: very Special Agent

Pat Thomas

They're a flinty-eyed bunch at the police pistol range on the outskirts of St. Petersburg, Fla. Up "on the line" they're squeezing off round after round at black-hearted targets down range with grim concentration, while those awaiting their turns talk of the relative stopping power of .38's and .357 magnums.

But something strange is about to happen.

Into this noisy milieu of people practicing with deadly determinations to shoot people, walks Suzanne Montero of NOAA and...well, she's *different.*

Women are not all that uncommon at shooting ranges, but an undeniable fact is that Suzanne Montero is pregnant and she has every intention of standing up there in that miasma of burnt powder and gunoil and blasting away at those black-hearted targets with her own .38 caliber Police Special revolver.

She calmly straps her pistol belt above her stomach, buckles on a carpenter's apron to hold loose cartridges below her stomach, and, undoubtedly aware of the figure she cuts, steps up to the firing line. The flinty eyes widen as she passes the qualifying test with ease.

Some day her youngest daughter, Anita, who's now 4 years old, will be able to relate the tale of how she—unborn, but alive and kicking—and her mother participated in firearms qualification. It's a story Suzanne Montero likes to tell.

Montero is a Special Agent for the National Marine Fisheries Service and, as might be expected, she's had her share of excitement and out-of-the-ordinary experiences. She works out of the Southeast Regional Law Enforcement Division in St. Petersburg and can spin some pretty salty yarns about her adventures as she investigates alleged violations of the Marine Mammal Protection Act, the Endangered Species Act, and the Lacey Act (which concerns the transportation of illegally taken wildlife). She also has participated in U.S. Coast Guard aircraft surveillance patrols for enforcement of the Fishery Conservation and Management Act and has served aboard local Coast Guard cutters and U.S. Customs patrol vessels involved in general law enforcement activities.

She's come a long way from that 1960's summer in Alexandria, Va., when she joined the Defense Supply Agency as a secretary stenographer. A native of Atlanta, Ga., she moved to the Washington, D.C., area to attend high school while her father worked for the Veteran's Administration. When her family moved to Florida she went along, continuing her secretarial career with the Defense Contract Administration Services Office in St. Petersburg.

Montero began her career with NOAA in 1974 as a secretary with the Fisheries Service's Law Enforcement Division. Within 2 months she moved into an "Enforcement Clerk" position and, according to her, "things have never been the same since."

Item: She was the first NMFS woman

Credit: NOAA

DANGER
INTAKE

Credit: NOAA

Montero qualifying on the pistol range. The NMFS Special Agent resorted to an unorthadox arrangement of gun belts. (See story.)

to complete the Treasury Department's Criminal Investigator School where she qualified as "Marksman" in the standard and night pistol courses and "Sharpshooter" in the combat course. (Unfamiliar with the boom and bang of the firing range as a fledgling "shootist," she scored a miserable 30 out of a possible 300 points on her first day of target practice. Undaunted, she returned the next day and qualified.)

Item: She attended the Air Force Water Survival School in Homestead Air Force Base, Fla., where she learned such skills as deploying a life raft, making fresh from salt water, and emergency signaling in case she was cast adrift at sea from a downed plane. (As part of this training she was required to learn to release herself from a parachute after landing in the sea. The school had rigged up a system whereby trainees were towed kite-like behind a launch and then released to float down under their parachute. When Montero's turn came, winds had picked up to 30-knot gusts which slammed her into the ocean with such force that her chute harness was knocked askew, putting the release mechanism out of reach. Unable to free herself from the billowing silk, she faced a quick end by drowning until the launch crew alertly ran over the parachute to collapse it and allow her time and slack enough to save herself.)

Item: She received specialized training in criminal interrogation and police photography. (Photography, with Montero posing as a model, was to play a part in one investigation; but more of that later.)

Item: In 1976, she qualified for the position of Special Agent while working on a degree in Police Administration at St. Petersburg Jr. College. In 1978 she received a NOAA Full Time University Training Scholarship and attended the University of South Florida for a year as a criminal justice major. She received her degree in 1980.

Item: Montero has served as the chairperson for the local Law Enforcement Liaison Group, a member of the Federal Criminal Investigator's Association, and, with her husband, Dario, works with the Seminole Volunteer Fire Department. With her full time NOAA job this makes for busy days, but she still finds the patience and energy to make a home for her three children, ages 4, 7, and 14.

Things have calmed down a bit since those hectic early days as a gun-toting agent in the field. She runs a branch now, with all of the desk work a supervisory position entails, but she could go out on assignment any time and she still carries a pistol. It's not to intimidate turtle rustlers. She used to go on ten day patrol cruises with the U.S. Coast Guard in the Gulf. They never knew whether

the boat they were boarding—perhaps suspecting some relatively minor fishing violation—was involved in smuggling drugs in which case the boarders might well be outgunned by the boardees.

She and her fellow agents don't go on patrol with the Coast Guard much any more. On-board observers have pretty much taken the place of agent spotters in fishery violation work. The St. Petersburg agents do operate two small craft making local inspections, looking, perhaps, for stone crab traps which have been left out illegally after the season is over.

But protecting sea creatures frequently requires some dry land detective work. Take the case of John Smith (not the person's real name).

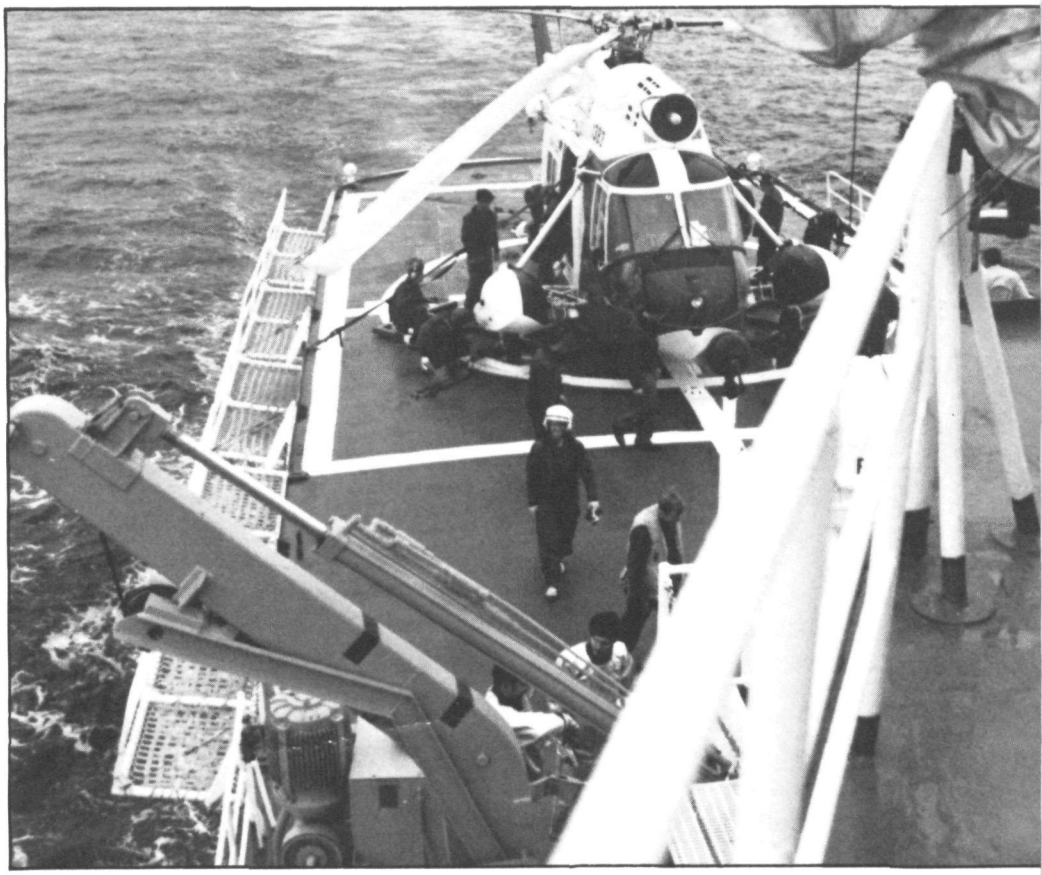
Smith was suspected by the NMFS of buying and selling porpoises illegally for entertainment purposes. Like Pinocchio in the child's story, the protected marine animals would be trained to perform with little thought to their health or comfort.

Montero recalls three distinct episodes in which she played a role in building a case against the elusive Smith.

The first was as a photographer's model. An undercover agent had set up a "buy" at an airport and Montero and another agent were on hand to photograph Smith *flagrante delicto*. Montero posted herself between the photographer and the point where the buy was to take place and pretended to be posing for fashion pictures. As she smiled and preened she felt silly, for she knew that the camera was directed not at her, but just beyond where the deal was going down. Worse, she couldn't look behind her to see how the operation was going. The buy went off as planned and another bit of damning evidence was added to Smith's file.

Montero again assumed an alias in the Smith case as the NMFS agents tried to pin down exactly where he lived. They knew the general area and suspected a particular house but wanted to be sure. After considering and rejecting several James Bondian ploys Montero, posing as a motorist with car trouble, boldly walked up to the door and knocked. The suspect's address was verified when Smith himself answered the door. He was most courteous, Montero reports.

Montero wasn't taking any chances in her third encounter with Smith. This time the assignment was to try to strike up a conversation with the suspect during a commercial airline flight in hopes that he would let slip self-incriminating evidence. Fearing that she might be recognized by Smith as she had been present at the airport meeting and at his house, Montero wore a red wig and dark glasses as she boarded the aircraft. She had arranged with the airline for the seat beside "J. Smith" as shown on the plane's seating plan. She couldn't help but feel nervous. There was always the chance she would somehow give herself away. How would this man react if he found he was being questioned by a Government agent?



Credit: NOAA

As ship's crew tie down a surveillance helicopter, Montero debarks and strolls forward as the Coast Guard vessel gets underway again.

As it turned out, Montero's disguise was perfect. She was not recognized. There was a catch, however. "J. Smith" it seems was not *John* Smith, the porpoise exploiter. The "J." was a feminine initial, and Montero, still in her wig and dark glasses, and Mrs. J. Smith, a pleasant little woman who would never think of hurting a poor sea creature, rode from Tampa to Miami side by side chatting about everything but marine mammals. Win some, lose some.

Are there disadvantages in doing what is usually considered a man's job? Montero sees signs of sexism in her day to day work—the title of the shop she runs (Staff Services Branch) implies a supporting role, and when she goes to meetings with men, they may remember she was once a secretary and ask her to take notes using her shorthand skill—but in general she takes things as they come and doesn't let little matters bother her. A good nature helps.

Once, aboard a Coast Guard patrol vessel, the watch officer talked her into making the traditional "lights out" announcement on the ship's speaker system. Feeling a bit like Wendy saying good night to the lost boys in *Peter Pan*, Montero heard cheers from the sacked-out sailors below when the announcement was over. She discerned a subtle difference in the little joke, however, when they asked her to make a record of the announcement. She politely refused. No hard feelings...

It's this sense of discretion, perhaps, added to a certain drive, a willingness to learn, and the ability to keep her wits about her that makes NOAA's Suzanne Montero a very Special Agent. ■

CITY-SCAPE

Florida's Glamorous Gold Coast

"Miami Beach... fun capital, sparkling palm-lined beaches, lavish hotels, and endless fun-filled days and nights in this gentle subtropical climate spell vacation magic to millions each year," according to the guidebook. And we can't argue with them. It certainly *looks* great.

A NOAA survey crew composed of pilot Lt. Terry M. Laydon, co-pilot Lt. Marcella Bradley, and photographer Larry Franklyn, took this aerial photograph of the central portion of the slender, 7½ square mile island from 1,930 feet last February.

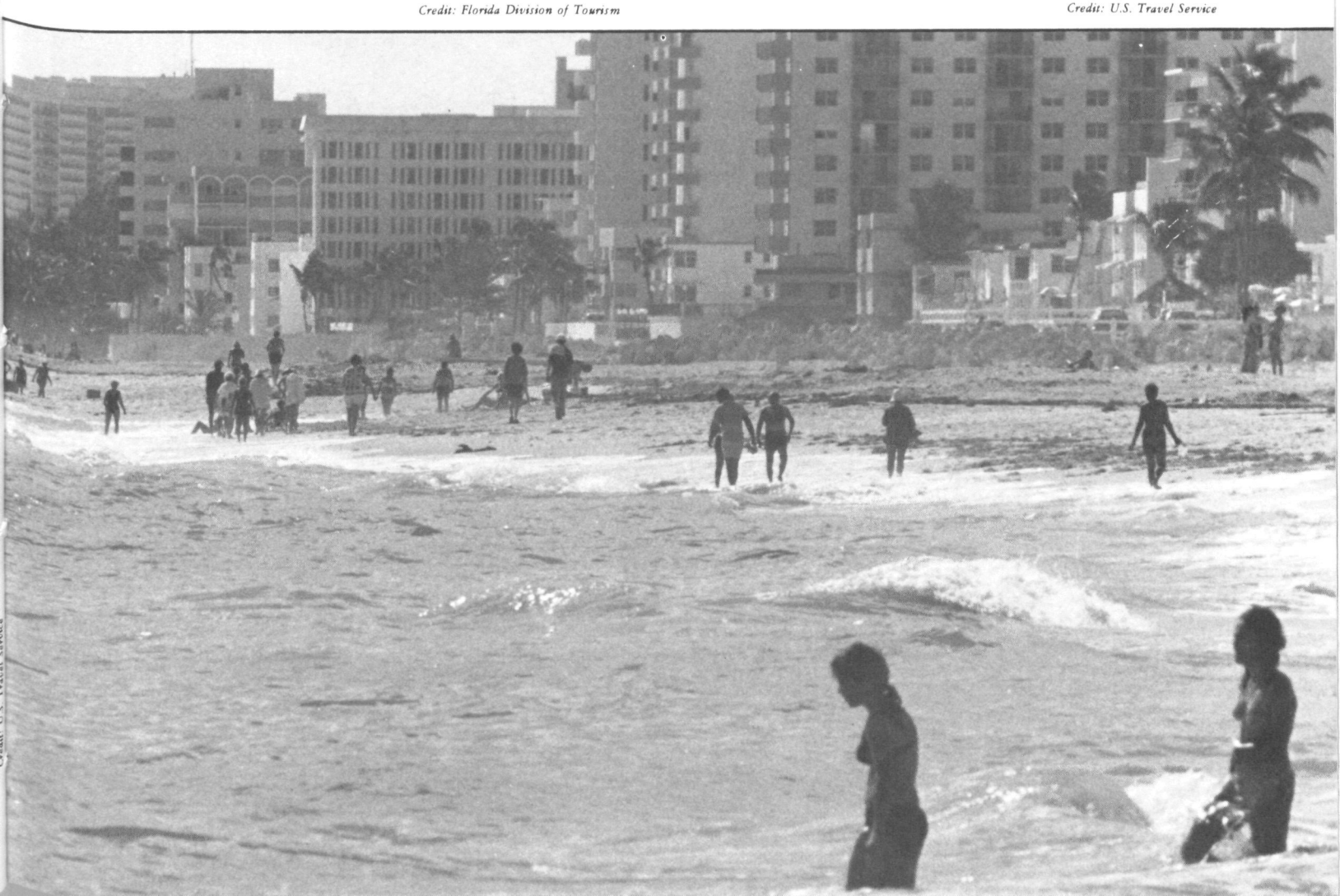
At the bottom, jutting into Biscayne Bay to the west of the grassy Bay Shore Golf Course and City Park are the four Sunset Isles. At the center of the picture, Arthur Godfrey Road slants eastward to join Indian Creek Drive, and then the famous Collins Avenue running north and south along the beach. Indian Creek flows just behind the ocean front property.

The conventional photos show some of the area's fantastic architecture—looking north past the Arthur Godfrey Road bridge and looking south towards the bridge in the distance.

Credit: NOAA

Credit: Florida Division of Tourism

Credit: U.S. Travel Service



Credit: U.S. Travel Service

Climate Support For The Nation's Defense

Roland D. Paine

A joint-use computer facility, part NOAA and part Air Force, is paying off—

For the Navy, which is updating its 20-year-old ocean basin climate atlas,

For hundreds of private firms and individuals, who every day obtain climate information for a wide variety of uses,

And of course for NOAA and the Air Force, who jointly run the computers, provide much of the back-up data, and use the big machines constantly to fulfill their mission assignments.

Apparently unique to the Federal Government, this joint cooperative arrangement is based at the National Climatic Center (NCC), part of the Environmental Data and Information Service. Housed in the historic Federal Building in Asheville, N.C., it also includes elements of the Air Force's Environmental Technical Applications Center and the Naval Oceanography Command.

NCC is the world's largest repository of climate data. "Without our close relationship with the Air Force and the Navy," says Daniel Mitchell, NCC Director, "we might have never obtained some of the invaluable oceanographic and meteorological data sets that we now possess—vital parts of the history of the world's climate."

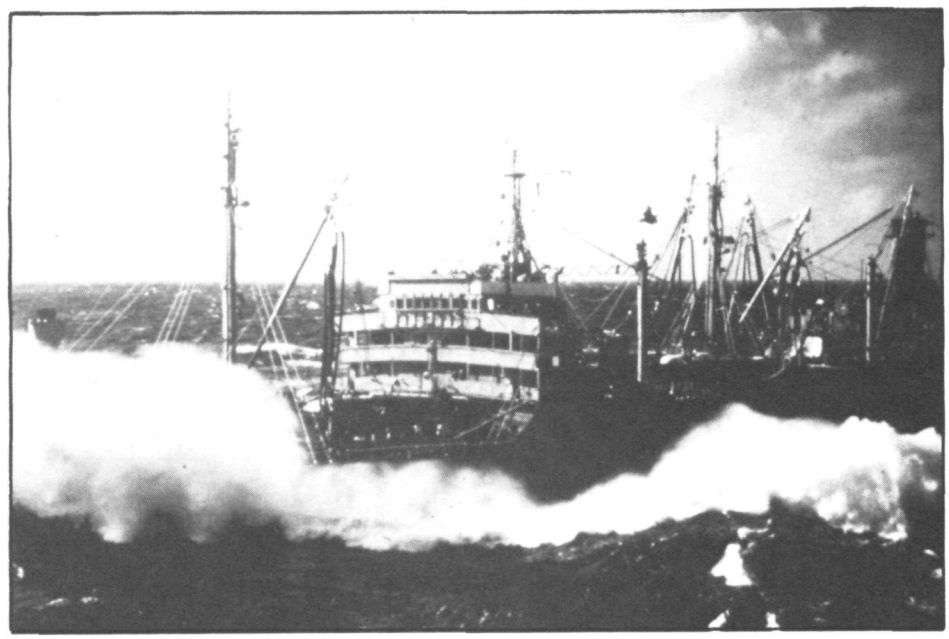
The center collects and stores all the weather data amassed each day by the National Weather Service, the Air Force, and the Navy, and collects data from countless other sources throughout the world.

A major element in the collection was stimulated some years ago by the Navy. "Early on, NCC only had data from land stations," said Cdr. Thomas G. Fitzpatrick, commanding officer of the Navy detachment there. "Because of its needs, the Navy pushed the issue of ocean climate data, and now NCC has the largest set in the world, which we use and contribute to regularly."

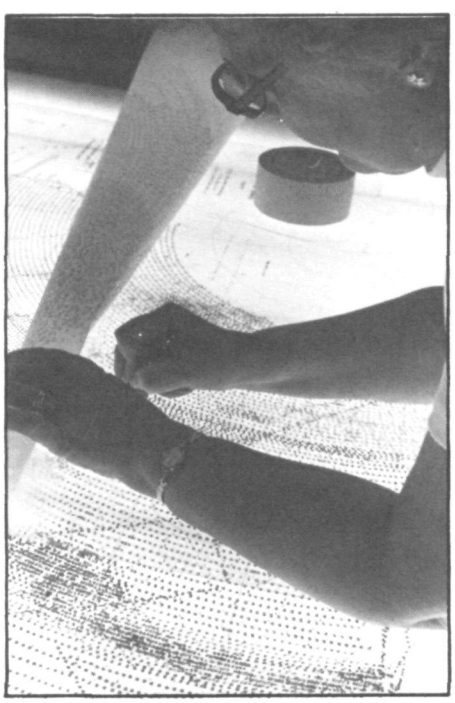
As part of its 7-year project to update the ocean data base, the Fleet Numerical Oceanography Center in Monterey, Calif., wanted to generate ocean wave data for the ship design community, and constructed a computer model to keep track of all energy in the world's ocean continuously. Using NOAA and other data, the Navy facility generated 20 years of historical climate data in the Atlantic and 12 years in the Pacific.

The Navy has arranged for the center to house and make available this data set to shipping firms, oil companies, and others with extensive operations at sea.

The Navy's new atlas, now in the process of publication, provides both operating climatic data useful to its operating forces at sea, and "hindcasts"—computer-derived histor-



Credit: U.S. Navy



Credit: NOAA

ical data that is used by naval architects and marine engineers planning vessels or seaborne platforms for specific locations or sea conditions.

Another area of mutual benefit arose when the Navy sought a computer program to use for quality control of weather data from its ships. At the same time, scientists with the First GARP Global Experiment (FGGE), an international weather research project, were looking for the same thing.

The climatic center accomplished the design work for FGGE, and the Navy adopted the program for its own use.

Under the system, the computer inventories data every 2 weeks from each station, and identifies items that are missing or that appear to be inaccurate. Relayed back to the units or weather stations in question, this information enables them to analyze why their observations are not up to snuff—because of inexperienced personnel, unsuspected equipment failures, or other reasons—and correct the problem.

In all, the Naval unit stationed at Asheville provides climatological support to more than 150 Navy activities and units, including the Trident systems, operational support for the fleets, and the Department of Defense energy program. The Navy has projected an increase in its use of NCC's climate services of more than 40 percent over the next 5 years, and plans to shift much of its data archival functions to Asheville, upon which it will increasingly lean for data support and climate applications capabilities.

The Air Force is the other partner in the cooperative facility, and maintains a staff of about 83 people at its Global Climatology Branch in Asheville. The joint computer operation consists of one Univac 1100/10 computer and associated equipment operated by NOAA, and a second operated by the Air Force. The data sets are interchangeable, and each computer backs up the other when required. Tape drives, disk drives, card punch, and printer are switch-able between the two systems.

"The arrangement is highly efficient and enables us to provide the Air Force with special climate studies on demand," said Louis A. Westphal, Air Force branch chief. "As a recent example, we used the center's solar radiation data to help the Air Force design energy-efficient buildings at our bases around the world."

Because the National Weather Service's network of volunteer and cooperative observers provides finer resolution of weather features than is available from the stations of the Air Weather Service, the Air Force obtains this information from the center for use in meeting its legal and paralegal requirements.

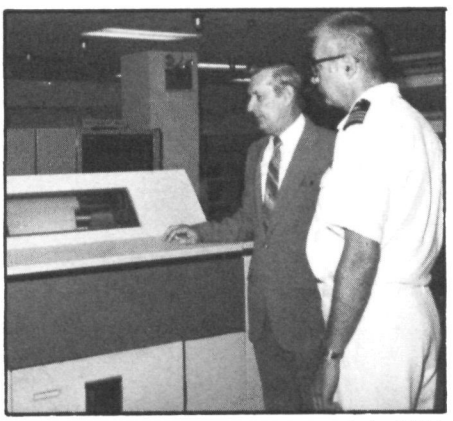
Conversely, the Air Force's unique data set showing three-dimensional analyses of cloud heights and amounts is one of several that are available to the public through the center.

NCC was established in 1946 as the National Weather Records Center, and moved from New Orleans to Asheville in 1951. The Air Force Global Climatology Branch, re-established in New Orleans in 1946 (it had been in the Pentagon during World War II) moved to Asheville concurrently with the center's move in 1951.

The Navy unit was also established in Asheville in 1951.

The National Climatic Center and the Air Force established the Federal Government's first joint-use computer system on May 20, 1968. The computers were acquired jointly in 1979, with the Air Force computer acquisition center acting as evaluating and selecting agent, and the Department of Commerce as contracting agency.

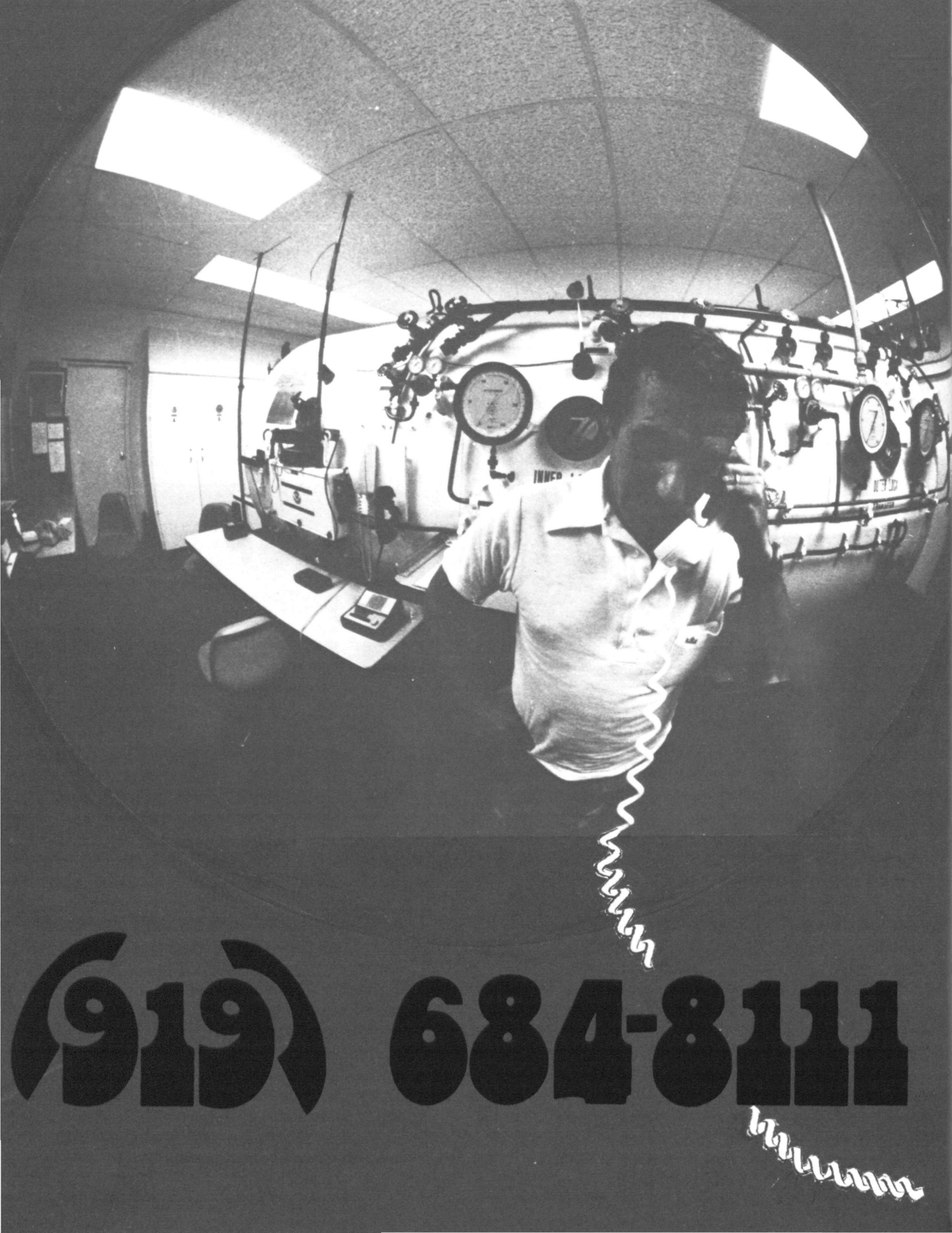
And the constant growth in services provided by the system—to civilians and the military, to Government agencies and commercial firms, to large organizations and individual citizens—is the testimony of its success. ■



Credit: NOAA

Credit: NOAA

Climate data for military use is produced through a cooperative arrangement at NOAA's National Climatic Center. Above right, Louis A. Westphal (left) Chief of the Air Weather Service's local office of the USAF Environmental Technical Applications Center, and Cmdr. Thomas G. Fitzpatrick, Commanding Officer of the Naval Oceanography Command Detachment, watch the Center's UNIVAC 1100/10 printer in operation.


(919) 684-8111

Handling Emergencies By The Numbers

Clay Rooks*

Clay Rooks is a science writer at Louisiana State University

Credit: NOAA

Several miles offshore a Gulf Coast diving team is working fifty feet down. Suddenly there's an emergency: Diver in trouble, treatment needed!

As the boat turns towards shore, the radio-telephone operator starts transmitting:

"New Orleans marine, New Orleans marine, New Orleans. This is WYR-5281, the *R.J. Russell*, over."

"New Orleans marine operator back to the *R.J. Russell*. Go ahead."

"We have an emergency. Get me the diving accident hotline—number 919-684-8111—collect, over."

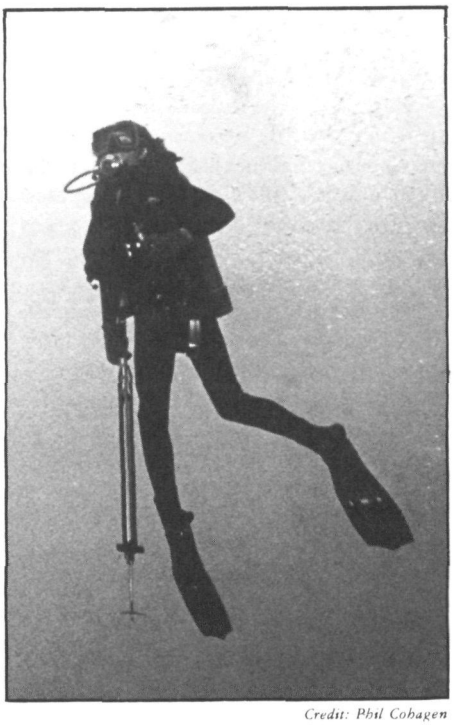
Within minutes the emergency is being handled by the Diving Accident Network. The diver's recovery chances have just increased greatly.

This scenario is now possible thanks to three Federal agencies. The Diving Accident Network (DAN) was established by the National Oceanic and Atmospheric Administration, the National Institute for Occupational Health and Safety, and the Department of Energy to aid in any diving emergency anyplace in the United States.

The nationwide hotline can provide expert medical advice to rescuers and physicians for treating a diving accident. Hotline physicians can advise and establish coordination of emergency services. If necessary, the caller will be given advice on how to obtain emergency transportation to the nearest medical facility capable of handling diving-related emergencies.

An average of 125 persons die each year in diving accidents. Dr. Donn Bowers, president of the Gulf Coast chapter of the Undersea Medical Society, says that the most common medical emergencies in diving are decompression sickness (the bends) and gas embolism (bubbles in the blood stream).

The bends are caused by nitrogen absorbed in the body tissues (while breathing underwater) turning gaseous before the diver can breath it out. In severe cases, the bends can produce paralysis, unconsciousness, arthritic-like symptoms and, sometimes, debilitating pain.



Credit: Phil Cohagen

Clip and Post

IMPORTANT TELEPHONE NUMBERS IN THIS DIVING AREA INCLUDE

Diving Accident Network hotline (any time) (919) 684-8111

Recompression chamber _____

Rescue _____

Coast Guard _____

Diving Doctor _____

Gas embolism is a trauma that can occur in water as shallow as 4 feet deep. If a diver rises too rapidly, the pressurized air breathed underwater over-expands in the alveoli (air cells) in the lungs. This forces gas into the blood stream, which carries it to the heart, and then to the brain. If gas bubbles reach the brain, they can produce stroke-like symptoms.

Dr. J. Morgan Wells, director of NOAA's Diving Office says deaths most often occur when the two conditions are misdiagnosed and not properly treated. Other victims die because many hospitals lack the recompression chambers needed for proper treatment, he adds.

This is where the Diving Accident Network becomes most important. The DAN telephone number reaches the operator in the Telecommunications Unit of the Duke University Medical Center in Durham, N.C. The operator will then connect the caller with an experienced physician, trained in hyperbaric medicine, available 24 hours a day.

The physician at the DAN center will either advise the caller or put him or her in contact with the nearest regional coordinator of the network. Each region has trained medical staff, 24-hour service, and suitable pressure chambers available for treatment. The regional coordinator will help direct the patient to these services and provide advice on treatment and transportation to the nearest pressure chamber.

The regional coordinators are located at Seattle, Wash.; Honolulu, Hawaii; Santa Barbara, Calif.; Milwaukee, Wis.; New Orleans, La.; Philadelphia, Pa.; and Durham, N.C.

Emergencies don't keep office hours so the hotline is open 24 hours a day, year round to serve recreational and working divers.

That number again—919-684-8111. It's a lifesaver. ■

Locking in freshness

An Historic Look At Seafood Preservation

Joseph Pileggi

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There is a story, probably apocryphal, that the American food processor, Clarence Birdseye, during a stay in Labrador, observed the fish taken from the sea in sub-zero temperatures quickly became frozen solid. When thawed and cooked, these fish retained much of the texture and flavor of fresh fish. Birdseye, the story continues, was so impressed that he decided to try quick-freezing by mechanical methods, thereby engendering the packaged frozen food industry.

While the record fails to substantiate the details Birdseye undoubtedly was impressed by his observations of the effects of natural quick-freezing on fish. His later work on quick-frozen (he used the term "frosted") foods was a giant step in the evolution of food preservation, storage, and distribution.

From the dawn of human history, fish has been the most easily obtained source of protein food. But seafood tends to spoil to a greater degree than other animal protein foods like meat and eggs. Thus, to a certain extent, humankind's development has been determined by the success of the techniques used to preserve and store fishery products.

Methods to check bacterial and other forms of spoilage have been few in number. Curing by drying, smoking, and salting with common salt (in various combinations) inhibits, destroys, or controls bacteria in varying degree. Other salts, acids (such as vinegar), sugar, and certain spices and herbs have a similar use. Even fermentaton can be used to preserve if the process of decomposition is controlled. Using ice to cool slows down the multiplication of microorganisms and hard-freezing below a certain temperature suspends it altogether. Canning results in their destruction by heat.

Scenes from the Boston Fish Pier. In 1940 (opposite) handling of the catch, while somewhat primative by today's standards, was a model for the times. Below, wooden boxes of 1956 have been replaced by plastic containers.

Credit: NOAA

Freezing—the quicker the better

Technological advances in preservation methods have played an important role in the rapid development and effective use of fishery resources. The introduction of modern icing and freezing techniques, which have occurred principally in this century, promoted the large-scale expansion in the United States of North Atlantic fishing industry and the growth of the shrimp and tuna fisheries. Freezing of fish has developed into the most attractive and widely-used modern method for the preservation of food fish.

The artificial freezing of fish on a commercial scale in the United States began about 1865. Even prior to that time, fish caught through the ice in the Great Lakes were frozen by allowing them to remain on the ice for a few hours. The great improvement in the quality of frozen foods began in 1925 when the quick freezing of fish began. Soon thereafter, Clarence Birdseye promoted the idea that if great care were taken in selecting, handling, preparing, freezing, storing, transporting, and marketing, the product would be equivalent in quality of first-class fresh foods. He first demonstrated this system with fish fillets but soon expanded the line to include shellfish, vegetables, fruits, meats, and poulty.

Credit: NOAA

BOSTON FISH PIER

The foundation for the 20th-century expansion of the U.S. fresh- and frozen-fish business was laid in 1914 when the Boston Fish Pier, then the world's largest, opened for business.

Its icing and cold-storage plant was the Nation's largest devoted exclusively to the fishing industry. The improved facilities enabled landings to soar at that port from less than 100 million pounds in 1914 to more than 285 million pounds in 1930. But since then, Boston landings have been declining due to a drop in the stocks of cod and haddock in the North Atlantic.

Four technological developments stimulated the enormous expansion in Boston production. The first was trawling introduced from England. The second was the invention of the filleting process in 1922 and later the invention of filleting machines. The third development was the substantial improvement in methods of freezing and storing fish. The introduction of quick-freezing processes around 1926 aided the industry to enlarge its market still further. The fourth innovation was the introduction of refrigerated trucking service which expedited the transportation of fish and frozen fish from ports with no rail service to major consuming cities.

In 1953 frozen fish blocks were developed for cutting up into fish sticks and fish portions. These products have become quite popular with consumers and the fish portions in recent years are being merchandised by fast food chains. Firms are now conducting research making more desirable, more sophisticated products from fish blocks than the simple fish sticks and portions. The first trend away from rectangular portions was a diagonal cut which more closely approach the natural fillet cut because of its tapered edges. A trend in recent years is the forming of a natural fillet shaped portion by pressing minced frozen fish or small frozen fillet blocks into a tapered mold. The product has the appearance and appeal of natural-shaped fillets plus the exact weight advantage (portion control) which is almost impossible to obtain in a natural fillet but is so important to the restaurant and institutional trade. Another trend in this direction is the development of fillet-shaped fish logs. In this process, sections of blocks, which while still hard-frozen, are reshaped under tremendous pressure by a press. The logs are usually about 2 feet long and weigh slightly over 10 pounds. The dies can be almost any shape so that the cross-cut sections will resemble a natural fillet, a cod tail, or a round, octagonal, or other shaped portion. All are perfectly portion-controlled and the variations in weight, surface, and shape are infinitesimal.

Credit: NOAA

Gleaming blocks of ice are lowered into the hold of a New England fishing vessel in this 1956 photo. The ice will extend the freshness of the catch from the fishing grounds to dockside.

Canning—salmon leads the way

Next to freezing, canning is our most important method of food preservation and the only one that has been entirely developed during modern times. Drying and smoking originated in prehistoric ages. Salting and pickling were developed in the early dawn of the historic period. Natural ice has been used for many centuries for refrigeration. But canned foods were entirely unknown before the Napoleonic era. Since that time progress of this industry has been extremely rapid. Seafoods were among the first products canned and until very recent years our midwestern regions would have been unacquainted with such food as oysters, shrimp, and salmon were it not for canning. Canned foods have been marketable more readily than foods preserved in other ways and their sale has been increasing.

It was in the United States that canning was first developed on an extensive commercial scale. Most of our pioneer canners were mostly packers of fish and seafoods, with fruits, vegetables and preserves as secondary or incidental products.

Canning is said to have been introduced into the United States by Ezra Daggett and Thomas Kensett in 1819. They packed oysters and other seafoods in New York. William Underwood is credited with setting up a plant in Boston in 1820, packing lobster and fruit in glass. These men learned the art in England before emigrating to the United States. The Underwood plant was later reorganized into the firm of Wm. Underwood's Sons and still exists—the oldest in the United States.

Increase in canning was gradual over a period of 20 years beginning in 1844. The first big increase was attributed to the Civil War. Preserved foods were needed for feeding the troops, thus increasing the demand and creating additional consumers for canned seafoods. American G.I.'s became acquainted with canned products in the army. When they returned to civilian status, they demanded canned foods and introduced the products to their neighbors.

One of our most important fish canning industries, salmon, was born during the Civil War. Salmon is said to have been canned first in Aberdeen, Scotland, in 1824 and it is claimed that the first salmon canned on the American Continent was packed at St. Johns, N.B., in 1839 and in Maine shortly thereafter. However, it was never packed on as extensive a scale as oysters and lobsters. Neither at that time nor since has salmon packing been of importance on the Atlantic Coast. The real beginning for the industry was in California. It first became important on the Columbia River and developed fully when canning spread to British Columbia, Alaska, northern Japan, and Siberia in that order.

George and William Hume with their friend A.S. Hapgood were the creators of the Pacific salmon canning industry. The Hume brothers, Maine fishermen, went to California as Forty-Niners. They noticed salmon were plentiful in the Sacramento River and believed money might be made canning the fish. Returning to Maine, they induced A.S.

Hapgood, a lobster canner, to return west with them and the first Pacific salmon pack was made at Sacramento in 1864. The pack was a failure the next year because fish failed to appear, but fishing was reported good on the Columbia River, so the Hume firm moved their equipment to Eagle Cliff, Washington, about 40 miles up the river from Astoria, Oreg., and made the first pack of Columbia River salmon in 1866. Canneries became numerous along the Columbia River and as the sale of canned salmon increased steadily the industry sought new and profitable locations further north. Today Alaska is the most important salmon canning area, but its first cannery was not built until 1978 at Klawak, on Prince of Wales Island.

Canned tuna is one of the more recently developed canned fishery products, first packed commercially in 1909. According to those who are connected with the California fisheries, the packing of tuna was started by the

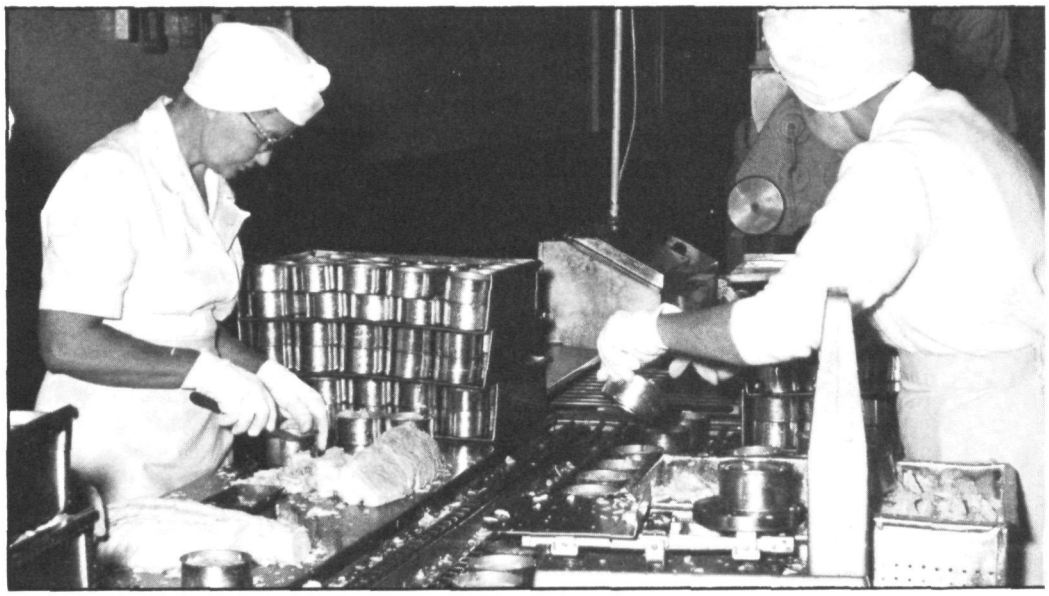
Do It Yourself?

Freezing: Write for "Home Freezing of Seafood" from Extension Business Office, Extension Hall 118, Oregon State University, Corvallis, OR 97331.

Smoking: Write for Food Science Technology Notes "Smoked Fish At Home—A Step By Step Guide" from Cooperative Extension Service, Virginia Polytechnical Institute and State University, Blacksburg, VA 24061.

Salting: Write for Food Science and Technology Notes "Salting Fish" from Cooperative Extension Service, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

Canning: Write for "Home Canning of Fishery Products" from Office of Public Affairs, (PA), National Oceanic and Atmospheric Administration, Rockville, MD 20852.



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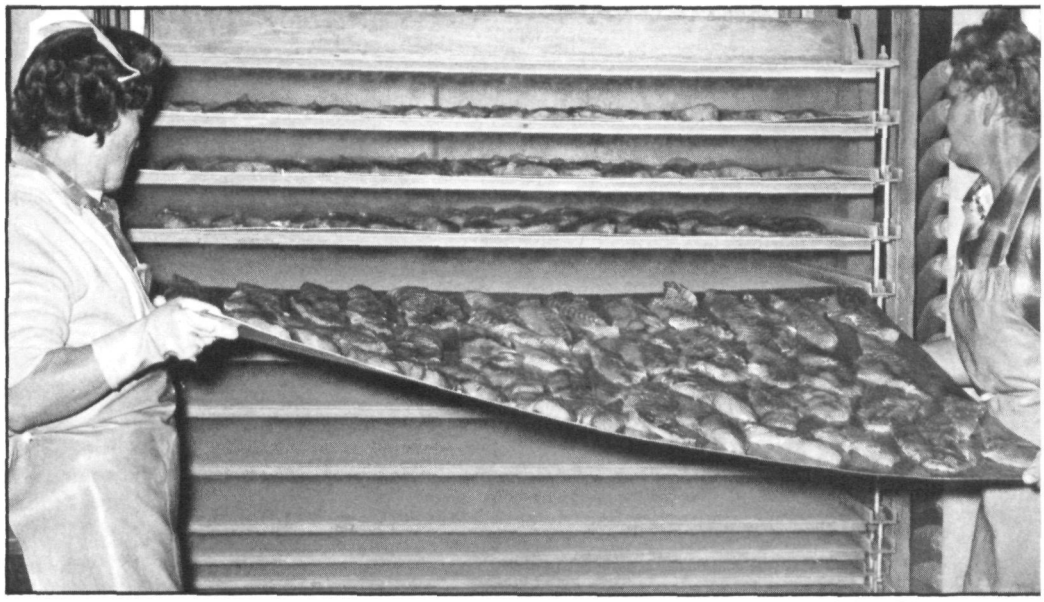


Credit: NOAA

Major methods of fishery products' preservation are shown: (from top) filling cans with tuna, cartons of fish fillets in cold storage, and trays of salmon being prepared for smoking.

Southern California Fish Company when in 1909 it canned 2,000 cases which were marketed by a distributor in New York City. The source of raw material at first was albacore tuna, which when cooked, all agreed, resembled chicken in taste and flavor. Later, other species of tuna and tuna-like fish were used like yellowfin, skipjack, and bonito. But of even more recent origin is the canned pack of fishery products for feeding pets. A record pack was reported in 1973 when 696 million pounds were canned. In 1979, the pack dropped to 476 million pounds.

About 160 species of fish are used regularly for food in the United States. Fifteen, such as salmon, tuna, sardines, herring, mackerel, shrimp, oysters, crab meat, clams, are canned regularly on a large commercial scale, while a number of others are packed occasionally or in quantities too small to merit separate recording in statistical reports. Over the past 100 years, the U.S. catch has varied greatly in species composition, due in part to changes in abundance of the various stocks, to the discovery of new resources and processing techniques, and to changes in consumer tastes.

Perhaps not even the visionary Clarence Birdseye could have foreseen preservation techniques extended to today's convenience food when first he saw the frozen fish of Labrador.

He most certainly could not have predicted the growth of the American fishing industry which now produces food and industrial goods valued at $7 billion annually and employs more than 250,000 workers. Nor could he have imagined the role of an agency such as NOAA with its fishery products inspection and certification program which assures the consumer that the product was processed from wholesome, acceptable quality raw materials in a sanitary manner.

Relatively recent changes in the waters and habitats capable of supporting aquatic life have been created by the pressures of increasing population and industrial development. Pressures on the Nation's fishing industry notwithstanding, an estimated 90 percent of the world's animal protein lies in the ocean. Seafood storage, preservation, and distribution in the U.S. and around the world has become increasingly more important as the ocean's comparatively untouched food sources are developed to feed an ever-growing population. ■

Buying Frozen Fish

Fishery products that are sold in the frozen form are usually packed during seasons of abundance and held in cold storage until ready for distribution. Thus, the consumer is given the opportunity to select different species of fish throughout the year. High quality frozen fish that are properly processed, packaged, and held at 0° F. or below, will remain in good condition for relatively long periods of time. Frozen fish may be purchased by the pound in any of the following market forms—whole, dressed, steaks, fillets, chunks, portions, and sticks.

Frozen fish of good quality have the following characteristics:

Flesh: Should be solidly frozen when bought. The flesh should have no discoloration or freezer burn. Virtually all deterioration in quality is prevented when fish are properly held in the frozen state. Frozen fish which have been thawed and then refrozen are poorer in quality.

Odor: Frozen fish should have little or no odor. A strong fish odor means poor quality.

Wrapping: Most frozen fillets, steaks, chunks, portions, and sticks are wrapped either individually or in packages of various weights. The wrapping should be of moisture-vapor-proof material. There should be little or no air space between the fish and the wrapping.

Buying Canned Fish

A wide variety of canned fish and specialty items is available on the market today. The most abundant varieties of canned fish are tuna, salmon, mackerel, and Maine sardines.

Tuna:
Several species of fish are marketed as tuna, all of which are equally desirable to the homemaker. On the Pacific coast, the catch includes albacore, bluefin, skipjack, and little tuna are taken on the Atlantic coast. Albacore has lighter meat than the other species and is the only tuna permitted to be labeled as "white meat" tuna. The other species are labeled as "light meat" tuna. Canned tuna is available in three different styles of pack. The pack does not indicate a quality difference but refers to the size of the pieces in the can.

Fancy or solid: The cans usually contain 3 or 4 large pieces packed in oil. This pack is ideal for cold plates or for recipes where appearance is important. It is the most expensive pack.

Chunk: The tuna is cut into convenient sized pieces and packed in oil. It is especially adaptable to salads and other dishes where chunks of tuna are desirable. It is the moderately priced pack.

Flaked or grated: The tuna is cut into smaller pieces than the chunk style and also packed in oil. It is excellent for canapes or sandwiches where tuna is blended into a paste. It is generally lower priced than the preceding packs.

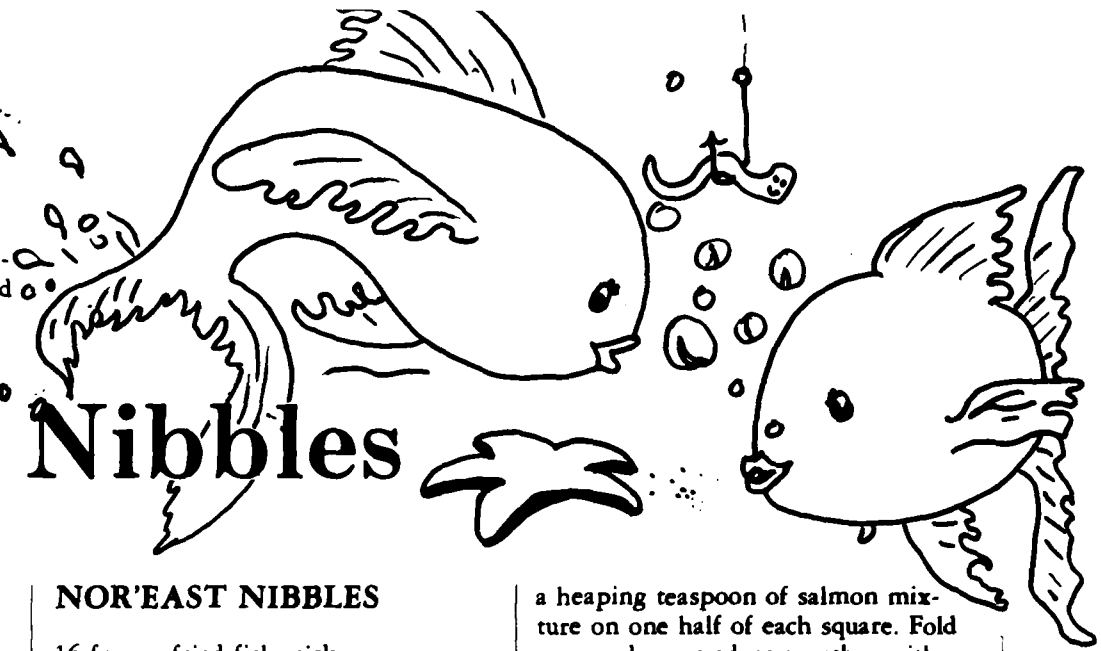
Canned tuna may be purchased in cans that contain 3¼, 3½, 6, 6½, 7, 9¼, 12½, and 13 ounces.

Salmon:
Salmon canned on the Pacific coast are of five distinct species and are usually sold by their names, since they indicate the differences in the type of meat. The differences are a matter of color, texture, and flavor. The higher priced varieties are deeper red in color and have a higher oil content. In descending order according to price, the grades of salmon are red or sockeye salmon; chinook or king salmon; medium red, coho, or silver salmon; pink salmon; and chum or keta salmon. Canned salmon may be purchased in cans that contain 3¾, 7¾, and 16 ounces.

Mackerel:
May be purchased in 15-ounce cans.

Maine sardines:
May be purchased in cans that contain 3¾ or 4 ounces.

These are great any time during the year but especially appreciated by your guests during the coming holiday season. These nibbles are easy to fix, great to taste, and will have your family and guests amazed at your skill and ingenuity.



Nautical Nibbles

TUNA TOMATO TEASERS

1 can (6½ or 7 ounces) tuna
1 package (3 ounces) cream cheese, softened
1 ripe avocado, mashed
1 tablespoon lemon juice
1 teaspoon chili powder
½ teaspoon salt
½ teaspoon liquid hot pepper sauce
½ teaspoon Worcestershire sauce
2 pints cherry tomatoes

Drain and flake tuna. Cream the cheese and avocado. Add seasonings and tuna. Mix thoroughly. Chill. Wash tomatoes and hollow out centers. Turn upside down to drain. Fill each tomato with a heaping teaspoonful of tuna mixture. Makes approximately 40 hors d'oeuvres.

TUNA CHEESIES

1 can (6½ or 7 ounces) tuna
1 cup shredded cheese
¼ cup butter or margarine, softened
2 tablespoons lemon juice
1 1/3 tablespoons grated onion
1 teaspoon Worcestershire sauce
½ teaspoon paprika
3 drops liquid hot pepper sauce
30 melba toast rounds

Drain and flake tuna. Cream the cheese and butter. Add seasonings and tuna. Mix thoroughly. Spread each toast round with approximately 2 teaspoonfuls of tuna mixture. Place on a baking pan, 15 by 10 by 1 inch. Broil about 4 inches from source of heat for 3 to 5 minutes or until lightly browned. Makes approximately 30 canapes.

NOR'EAST NIBBLES

16 frozen fried fish sticks
½ cup grated Parmesan cheese
2 tablespoons butter or margarine
Sea Sauce

Cut frozen fish sticks into thirds. Roll each piece in cheese. Melt butter in a baking pan, 15 by 10 by 1 inch. Place fish in pan. Bake in a very hot oven, 450° F., for 8 to 10 minutes. Turn carefully. Bake 8 to 10 minutes longer or until crisp and brown. Drain on absorbent paper. Serve with hot Sea Sauce. Makes 48 hors d'oeuvres.

SEA SAUCE

1 can (8 ounces) tomato sauce
¼ cup chili sauce
¼ teaspoon garlic powder
¼ teaspoon oregano
¼ teaspoon liquid hot pepper sauce
¼ teaspoon thyme
⅛ teaspoon sugar
Dash basil

Combine all ingredients. Simmer 10 to 12 minutes, stirring occasionally. Makes approximately 1 cup sauce.

SALMON FLIPS

1 can (1 pound) salmon
4 slices bacon
¾ cup condensed Cheddar cheese soup
1 teaspoon horseradish
1 teaspoon instant minced onion
Dash pepper
Cheese Canape Pastry

Drain and flake salmon. Fry bacon until crisp. Drain on abosorbent paper. Crumble. Combine all ingredients except pastry. Roll pastry very thin and cut in 2½-inch squares. Place a heaping teaspoon of salmon mixture on one half of each square. Fold over and press edges together with a fork. Place turnovers on a baking pan, 15 by 10 by 1 inch. Prick top to allow steam to escape. Bake in a very hot oven, 450° F., for 10 to 12 minutes or until lightly browned. Makes approximately 80 hors d'oeuvres.

SKEWERED SCALLOPS

1 pound scallops, fresh or frozen
1 pint cherry tomatoes
2 large green peppers
1/3 cup lemon juice
3 tablespoons honey
3 tablespoons prepared mustard
2 tablespoons melted fat or oil
1½ teaspoons curry powder

Thaw frozen scallops. Rinse with cold water to remove any shell particles. Cut large scallops in half. Wash tomatoes and green peppers. Cut green peppers into 1-inch squares. Alternate scallops, tomatoes, and green pepper on 40 skewers or round toothpicks approximately 3 inches long. Place kabobs on a well-greased broiler pan. Combine remaining ingredients. Brush kabobs with sauce. Broil about 4 inches from source of heat for 5 to 7 minutes. Turn carefully and brush with sauce. Broil 5 to 7 minutes longer, basting once. Makes approximately 40 hors d'oeuvres.

Correction

On the Sea Fare page of the summer issue of *NOAA* magazine a mistake occurred in the listing of ingredients for "Fisherman's Delight." The final item should have read "1 pound sliced bacon."

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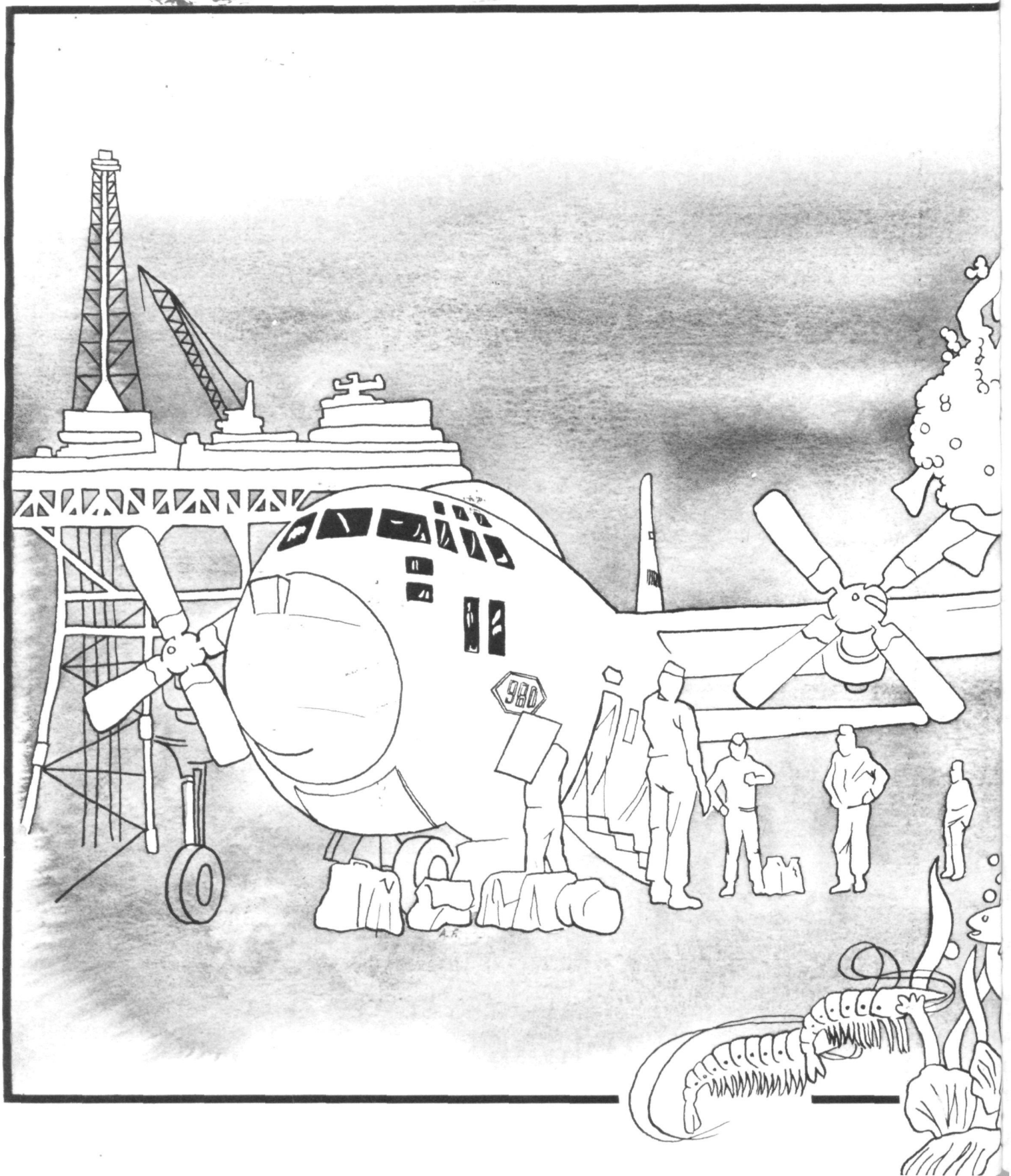
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