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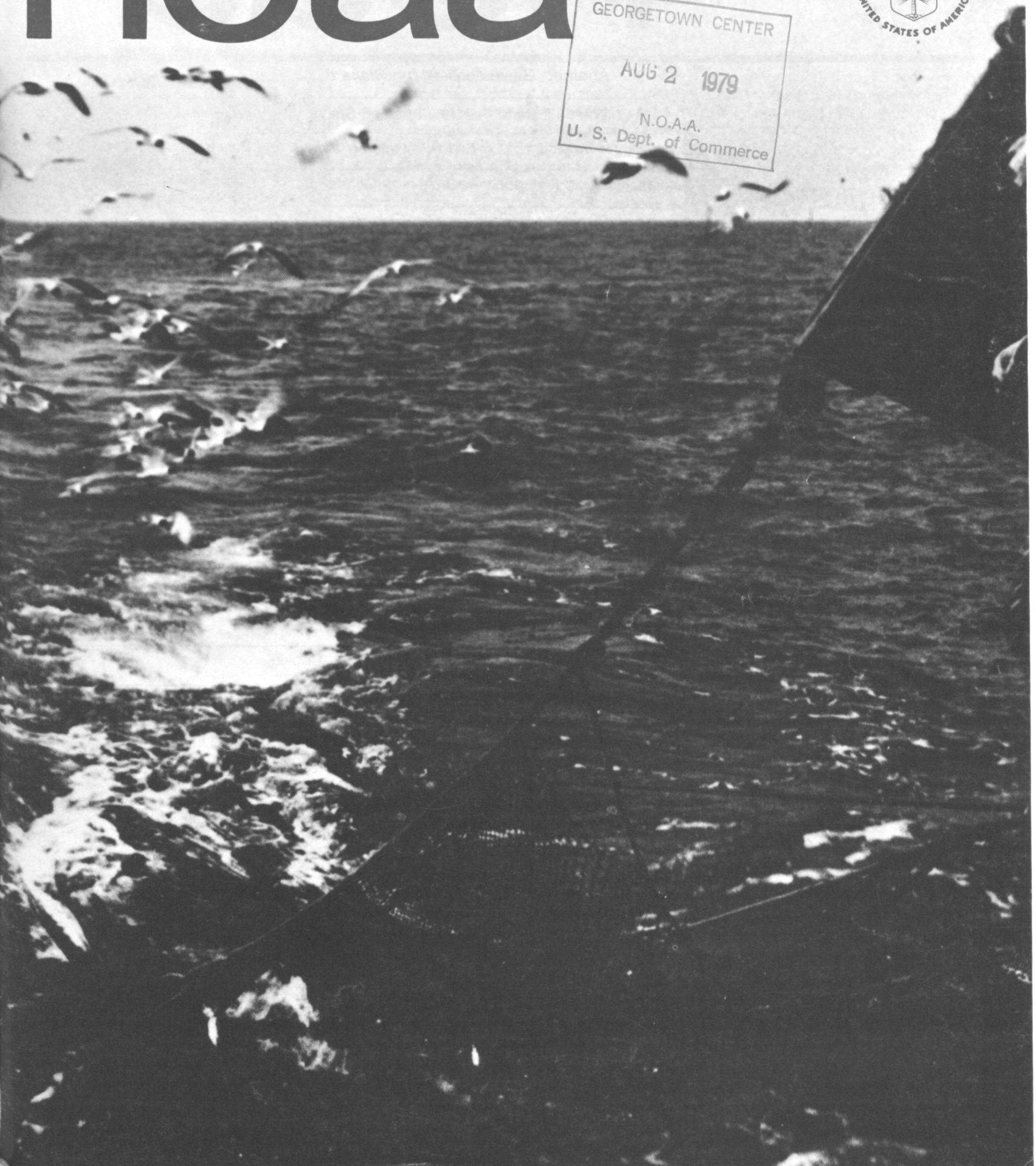

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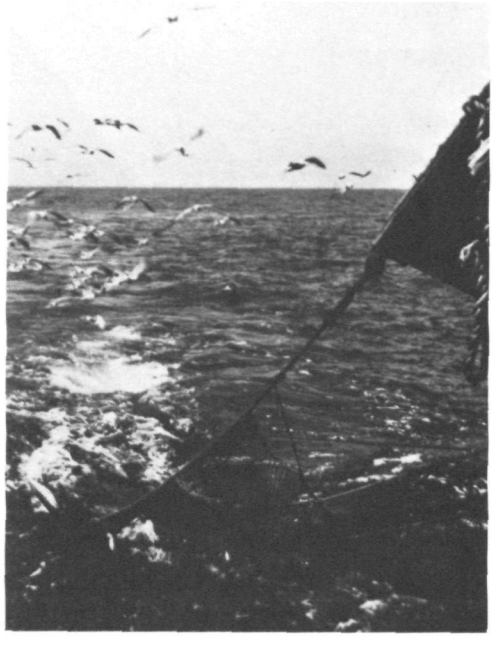

3 Another Galveston?— *by Richard A. Frank*

4 What's Behind the New England Standoff?— *by Gerald D. Hill, Jr.*

8 Galveston— *Victim of America's Worst Natural Disaster— by Patrick Hughes*

14 Could It Happen Again?— *by Charles G. Thomas*

16 Disaster Preparedness for Floridians— *by Thomas M. Leahy*

20 The Barrier Islands— *by Brian Gorman*

24 NOAA Profile: Don't Forget the People— *by Norma V. Reyes*

26 NOAA in the Chesapeake— *by Roland D. Paine*

32 Weather in Their Blood— *by Charles G. Thomas*

34 A Closer Look at the Sun— *by Richard E. Newell*

38 Fishermen's Friends in the Weather Service

42 Heat Wave— *by Carl A. Posey*

46 Safe Diving—Passport to a New World

48 Chemical Detectives Solve Riddles of the Sea— *by Carl A. Posey*

52 The View From Space

54 A Different World

58 Sea Fare: Summer Sizzlers for Easy Cookin'

60 NOAA/Update

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Another Galveston?

Readers should find "Galveston," an article in this issue of NOAA Magazine, a sobering experience.

Could we see repeated the tragedy of that Gulf Coast hurricane, the greatest killer of any natural disaster in American history? A better question may be when and where will a major hurricane strike one of our heavily populated, highly developed coastal areas, and how much death and destruction will it inflict?

The hurricane forecasting of NOAA's National Weather Service is outstanding, but forecasts and warnings alone cannot guarantee the survival of those in the path of a devastating storm. Factors other than those combine to make our hurricane peril a matter of critical national concern.

As many as 80 percent of those living or visiting in susceptible coastal areas have never experienced a hurricane. This has generated an insidious combination of unpreparedness and apathy, that grows more dangerous with each hurricane-free season. Humanity almost engulfs our prized coastal areas now, and development, if unchecked, will only intensify. Most do not comprehend their risk; many barrier islands could be totally inundated by a major hurricane, and evacuation planning is not adequate to the sudden demands that would be placed on escape routes.

Clearly the problem is one for our society to attack, and forthrightly. We might, for example, consider such policies as more aggressive use of planning mechanisms, mandatory disclosure of hazards in real estate transactions, tax incentives (and disincentives), insurance restrictions, limitation of development on barrier islands and low-lying coastal regions, and the systematic acquisition of hazard-prone areas for public recreation uses.

NOAA is taking action to deal with the hurricane peril:

- We are aiding communities to develop model evacuation plans—Ft. Meyers, Florida, and Galveston, Texas, are the first.
- We have changed our Coastal Zone Management regulations to require states to spend at least one-fifth of their second-year Federal grants on national issues, one of which is coastal hazards mitigation.

We are also considering other actions to deal with the problem, and our efforts will not cease. As examples:

- Stepping up our mathematical modeling of hurricanes so that we can better predict the nature and damage of storm surge and giving highest priority to the most densely populated areas.
- Improving NOAA's disaster survey teams to get more accurate data and to include others responsible for dealing with the hurricane peril.
- Developing pilot projects for coastal erosion atlases.
- Producing publications that describe barrier islands, including information on how to use them prudently.

History assures us that the hurricane experience will be repeated again and again; in this century alone, the United States has undergone no fewer than 129. There is every reason to expect that in the near future a devastating hurricane will kill hundreds, if not thousands, of Americans and wreak billions of dollars' worth of destruction—and we must do all we can to mitigate its effects.

George Santayana said that those who cannot remember the past are condemned to repeat it. Against the day of the next great storm, NOAA will do everything in its power to protect our people. But much of the ultimate obligation rests in the states and communities where the price will be paid. Satisfying that responsibility insofar as it is humanly possible will be difficult and often unpopular, but it will be a public service of the utmost importance.

Richard A. Frank
Administrator

The growth pains of fisheries management

What's Behind The New England Standoff?

By GERALD D. HILL, JR.

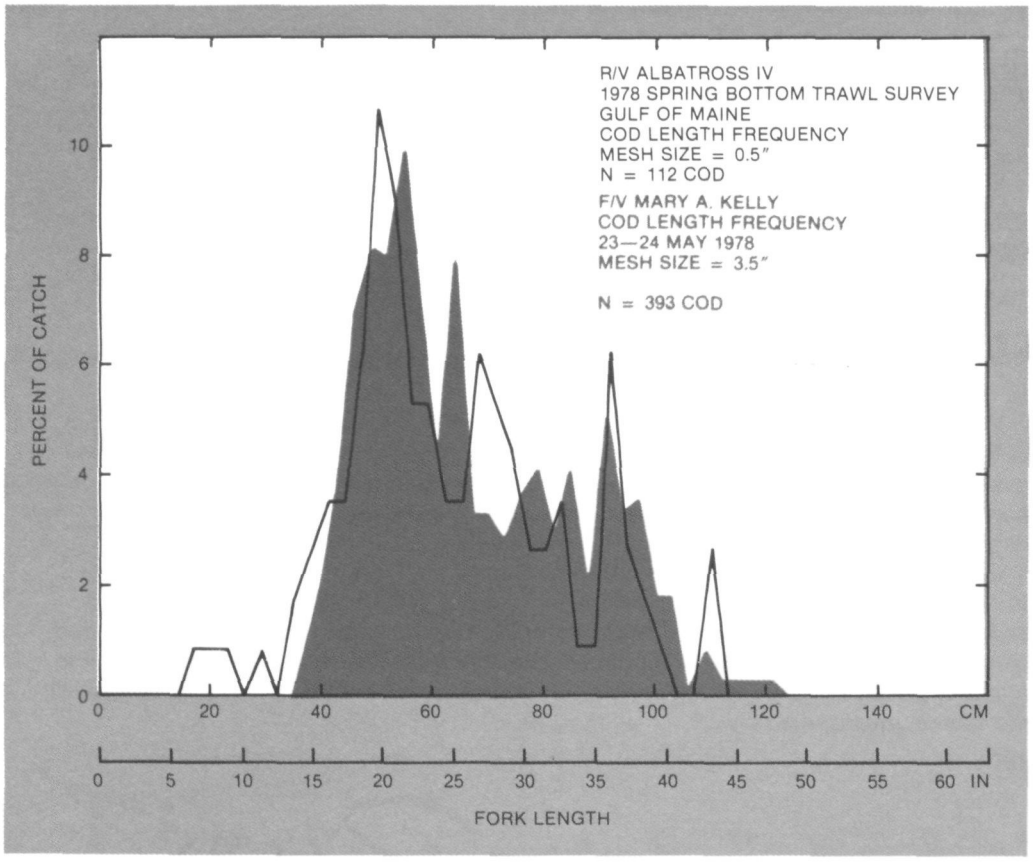
New England fishermen are angry.

A few years ago they were angry because huge foreign fishing fleets were sweeping up most of the fish that they depended upon to make their living. In response, the Fishery Conservation and Management Act of 1976 was passed. It limits the number of foreign fishing vessels and the amount of foreign catch. Competition from foreign fishermen decreased dramatically, and American fishermen generally supported the Act.

The Act also provides for conservation and management of all fisheries including the catch by U.S. fishermen. Catch limitations and other management measures have been applied to American fishermen for those species under fishery management plans.

New England fishermen again are angry. Some say they have never seen as many Atlantic cod and haddock off the New England coast as they have seen for the past two years, while at the same time the plan established by NOAA and the New England Fishery Management Council (set up under the Act) is restricting the catch of these two species, and of the yellowtail flounder.

Paradoxically, the biologists and statisticians who try scientifically to tote up the amount of fish in those waters—whose estimates are used by the Council—agree with the fishermen. There are a lot of fish out there right now, although not more than the biologists and statisticians "have ever seen," and perhaps not enough for the future.



Similarities in length-frequency distribution during separate 1978 surveys are apparent in this composite graph.

Then what's the problem?

Well, to use haddock as an example, during the first two years of the Act, 1977 and 1978, most of the fish in the population came from the 1975 year class. (A year class is all fish of a species hatched in a given year.) In all years other than 1975, though, the adult haddock spawned relatively few young fish, so there wasn't a continuing reservoir of fish to count on.

The biologists spotted this relatively large 1975 year class of haddock soon after it was spawned, and correctly predicted that there would be a lot of fish out there beginning in 1977 when the fish had grown to a catchable size. However, they, and the Council that determines catch limitations, knew that until another relatively large year class came along, there would be increasingly fewer adult fish out there. The biologists and the Council also knew that if most of those adult fish were caught before they had had a "good spawn," then there might be a long period of shortage ahead.

Fortunately for the haddock, enough of that 1975 year class survived to spawn another relatively large year class in 1978 (its first year of spawning). Accordingly, the Council relaxed its 1979 catch limitations on haddock somewhat, but its precautionary actions in 1977 and 1978 have left a bitter aftertaste in the mouths of some New England fishermen.

Key to all this, of course, is the reliability of the biologists' and statisticians' assessment of how many fish of what age are in the population (or stock). Here's how stock assessment works:

Scientists have been assessing fish stocks off the Atlantic coast for a number of years. The NOAA Northeast Fisheries Center in Woods Hole, Mass., uses three major sources of data in stock assessments—bottom trawl surveys conducted aboard NOAA research vessels, U.S. commercial and recreational fisheries catch statistics, and foreign catch statistics.

Dr. Fredric Serchuk, Chief of Fishery Analysis Investigation at the Center, noted that an assessment of a fish stock is a detailed and laborious examination of all available data on that stock. When completed, it provides us with estimates of the total number of fish in the population, the number of fish of spawning age in the population, and the number of fish

Bottom trawl surveys sample all sizes of a given species - from the "scrod" cod at left to the "whale" cod at right.

that are not yet of catchable size but that, minus any natural mortality, will join the 'catchable population' within the next few years.

"We also estimate the proportion of the stock that is dying naturally as well as that which is being taken by fishing," he added.

The Center has used two stern-trawling NOAA research vessels, Albatross IV and Delaware II, for its fall surveys since 1963 and its spring surveys since 1968. "Each survey requires 6 to 8 weeks to complete," said Serchuk, "and consists of approximately 300 to 450 bottom trawl tows of 30 minutes' duration. We survey the area between North Carolina and Nova Scotia."

The survey area is divided into surface and depth subareas. Within this checkerboard arrangement, fish stocks sampling takes place. Since depth contours are often irregular, the size of the subareas varies. The larger the area, the greater the number of trawl tows.

"The situation is not that much different from that of a pollster who seeks to determine public opinion by dividing the country into subareas depending on geographical or social differences and then sampling proportionately from the population within each subarea," Serchuk said.

Numerous joint and cooperative surveys have also been conducted since 1967 by research vessels from the Union of Soviet Socialist Republics, Poland, the two Germanys, France, Canada, Spain, and Japan. Lacking the continuity and standardized techniques of the Northeast Center surveys, these joint efforts are not normally used directly in making stock assessments, but they provide a crosscheck on the results of the NMFS surveys.

The total catch of each species from each tow is weighed and measured. Scales, otoliths (ear bones), stomachs, and gonads are removed and studied for information on age and growth, food habits, and maturity. The information is computerized for ready reference.

A common calculation made by the statisticians is of the average number of individuals of each species caught per tow throughout the survey area. This gives them a relative measure of the abundance of that species.

By reviewing average catch per tow over a period of time, scientists can see the trends or fluctuations in the abundance of the stock. In addition, because the trawls used in the surveys have a smaller mesh size than that used in commercial fisheries, they catch fish less than a year old. In this manner scientists get a preview of what the catchable populations may be two or three years later, when the fish have grown enough to be caught in the commercial nets.

Catch statistics reported by domestic and foreign fishermen provide the primary basis for estimating the present size of a stock. At the end of the year, the total weight of the catch of each species is converted into the total number of individuals in the catch of that species. In turn, this total number is converted into the number of individuals within each age group within the population, by sampling the catches and determining the age distribution of the samples. A mathematical procedure is used

to estimate the size of the stock and the mortality due to fishing at each age in all years for which catch data are available.

"The initial step in this method is to estimate the level of fishing mortality in the most recent year for which the catch in numbers by age is known or has been estimated," said Serchuk. "This estimate is critical, since the accuracy of the estimate of stock size for that year depends on the estimate of the level of fishing mortality for that year. For a given amount of catch, overestimating fishing mortality will result in an underestimation of stock size, and conversely."

According to Serchuk, fishing mortality can be estimated by using the relationship between the estimates of fishing mortality gained from catch data and the relative values for exploitation rates calculated from research surveys.

After current stock size is estimated from the reported catches and potential recruitment to the "catchable population" is estimated from research surveys, future stock levels can be projected under varying conditions of fishing mortality.

How reliable are these assessments? Fishermen claim that the scientists never take their samples where the fishermen actually fish, and as a result really don't have a good picture of the stocks. Say the scientists: quite the contrary. Perhaps we ought to refer to the analogy of the public opinion pollster mentioned earlier. If that pollster wanted to know the national attitude towards agricultural assistance programs, would he only sample opinions in major farming areas, or would he select opinions from around the country? It is the same situation for fishes in the Northwest Atlantic, according to Dr. Robert Edwards, Director of the Center.

Accordingly, the sampling done by the Northeast Center is statistically random. Although all of the subareas are sampled and each is sampled a certain number of times depending on its size (for reasons mentioned earlier), each trawl tow is performed at a site that has been randomly selected before the survey begins.

In addition, scientists make trips on commercial fishing vessels to sample those catches. Serchuk made one such trip on the fishing vessel Mary A. Kelly out of Portland, Me., in May 1978. In two days, the vessel caught 4,214 pounds of cod, 954 pounds of haddock, and 7,533 pounds of American plaice (a flounder).

The cod length-frequency distribution from the Mary A. Kelly shows distinct peaks at 22 and 26 inches. These lengths indicate the fish that were spawned in 1974 and 1973, respectively. Minor peaks at 34 and 36 inches correspond to cod spawned in 1971 and 1969, respectively. The length-frequency distribution for the cod caught by the Mary A. Kelly compares closely with the length-frequency distribution of cod caught during the 1978 research survey for the same area, the Gulf of Maine.

Length-frequency distributions obtained from haddock and American plaice caught by the Mary A. Kelly are also very similar to the results of the spring survey conducted by the NMFS scientists.

So far we've looked at what all this sampling tells us about the status of stocks in only a general sense. Now, let's take a closer look at one of the three species currently regulated and the source of much of the fishermen's ire—the cod. (Haddock and yellowtail flounder are the other two species).

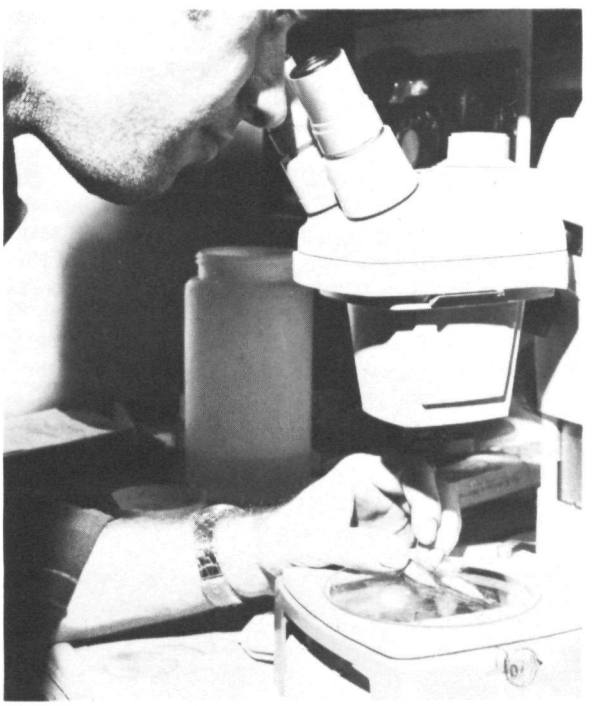
Sorting through a bottom trawl catch on the Albatross IV, scientists harvest a garden of marine life.

Several things have been learned about the cod stocks in the Gulf of Maine and on Georges Bank from the surveys conducted by the Service. Both botton trawl survey and commercial length-frequency data indicate that strong year classes (those fishes that were spawned in a given year) appeared on Georges Bank in 1971 and 1975.

On Georges Bank, year classes first appear in the research surveys as young-of-the-year fish less than 8 inches long; they later turn up in the commercial catch as 2-year-old fish 16–24 inches long. Thus, these strong year classes were noted by the scientists in 1971 and 1975, and by the commercial fishermen in 1973 and 1977, respectively.

The age composition of the 1977 commercial landings indicate that two-year-old fish (1975 year class) comprised 50 percent of the catch. The 1977 research survey shows that the number of fish which were two years old or older, and the total weight of fish, were among the highest for all surveys conducted during past years. However, the survey also shows that the numbers of 1-year-old and younger fish (1976 and 1977 year classes) were comparatively much smaller.

The research data, in conjunction with the



Weighing, measuring, examining, workers aboard the Albatross IV seek to determine the status of fish stocks.

commercial data, thus indicate that the Georges Bank cod stock size is higher than it has been since 1971, but that the fishery will likely have to rely on most of these same fish to support the industry at least until 1980, since the number of fish growing to a catchable size for the first time in 1978 and 1979 (the 1976 and 1977 year classes, respectively) will add little to the size of the catchable population.

In the Gulf of Maine, survey data and commercial data both show that one strong year class (1971) and two moderately strong year classes (1973 and 1974) have appeared since 1970. These year classes first appeared in the trawl surveys in 1971, 1973, and 1974 as young-of-the-year fish less than 4 inches long, and were later seen in 1974, 1976, and 1977 in the commercial catch as 3-year-old-fish. (Fish in the Gulf of Maine grow more slowly than those on Georges Bank.) These strong year classes account for the good catches in the past few years.

However, the relatively low catches of juvenile fish less than 8 inches long in the 1975–1977 research surveys possibly points to a below-average number of young fish entering the fishery during 1978–1981 and further suggests that the currently harvested age groups may have to sustain the fishery during the next several years.

What does all of this mean to the New England Fishery Management Council, which uses the information along with social and economic information when it develops a fishery management plan?

For the cod, the research surveys conducted in the Gulf of Maine and on Georges Bank confirm the fishermen's reports that there are presently a lot to be caught. The fish they are catching are from the strong year classes that the surveys discovered several years ago. The surveys also tell the Council that there have been no unusually strong year classes produced to replace those fish being harvested now.

The Council is faced with the problem of how, on the one hand, to let the fishermen catch as many fish as are economically feasible and, on the other hand, to ensure that those fish of spawning age in the population (which must bear the major responsibility for replenishing the species until at least 1981) not be reduced to such a low level that the likelihood of future spawning success is threatened.

What is the solution? Thus far, none that will satisfy everyone. The choice between continuing to catch large amounts of fish now (and running the risk or reducing the stocks to undesirable levels) and restricting the amount taken must nonetheless be made. □

It was America's worst natural disaster. Could it happen again?

Galveston

By PATRICK HUGHES

"With a raging sea rolling around them, with a wind so terrific that none could hope to escape its fury, with roofs being torn away and buildings crumbling . . . men, women and children . . . huddled like rats in the structures. As buildings crumpled and crashed, hundreds were buried under the debris, while thousands were thrown into the waters, some to meet instant death, others to struggle for a time in vain, and yet other thousands to escape death in miraculous and marvelous ways."

This is an eyewitness account of the great Galveston hurricane of 1900, the worst natural disaster ever to devastate an American community.

The storm cut off Galveston Island from the mainland and completely submerged it under the sea. In Galveston city alone, it killed at least 6,000 men, women, and children. It left 1,000 survivors naked, 5,000 more bruised and battered. In a 1,500-acre area of total destruction, 2,636 houses—nearly half the homes in the city—were swept out of existence. Elsewhere, at least 1,000 more were reduced to wreckage. Not a single building escaped damage; every survivor had faced death.

The Galveston hurricane was a far greater disaster than the Chicago fire of 1871, which killed 250 people, or the 1906 San Francisco earthquake, which killed 480, or the Johnstown Flood in 1889, which claimed 2,200 lives.

Galveston Island is a long, narrow barrier beach that runs parallel to the Texas coast some two miles away across Galveston Bay. The City of Galveston occupies the eastern end of the island. In 1900, the island and city were connected to the mainland by "the longest wagon bridge in the United States" and 3 wooden railroad trestles.

Galveston is literally a city built on sand. In September 1900, the sand was only 8.7 feet above sea level at the highest point. In most residential areas, street levels ranged from 4 to 7 feet, with an average elevation of only about 4.5 feet.

At the turn of the century, Galveston was the financial capital of the Southwest and one of the richest cities per capita in the United States. Its landlocked harbor was the deepest and best on the Gulf Coast.

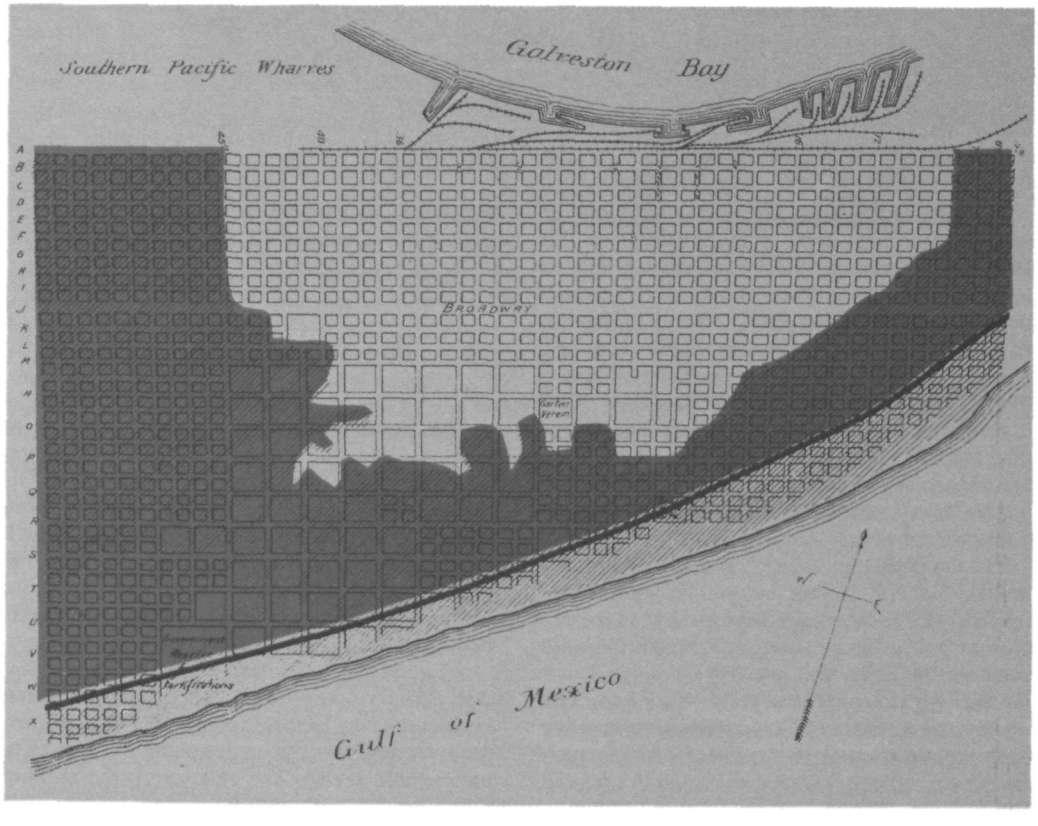
Galveston's semitropical climate, exotic foliage, and miles of beach also made it a prime resort area. It was largely a city of small, white buildings, with many lightly constructed frame houses, particularly near the beach on the Gulf side of the island. There also were massive, imposing mansions, however, some built at a cost of more than a quarter of a million 19th Century dollars.

The census of 1900 put Galveston's population at 37,789. Electricity had been introduced in the 1880's. There were 40 miles of electric street-car lines, 2,028 telephones, and 2 automobiles.

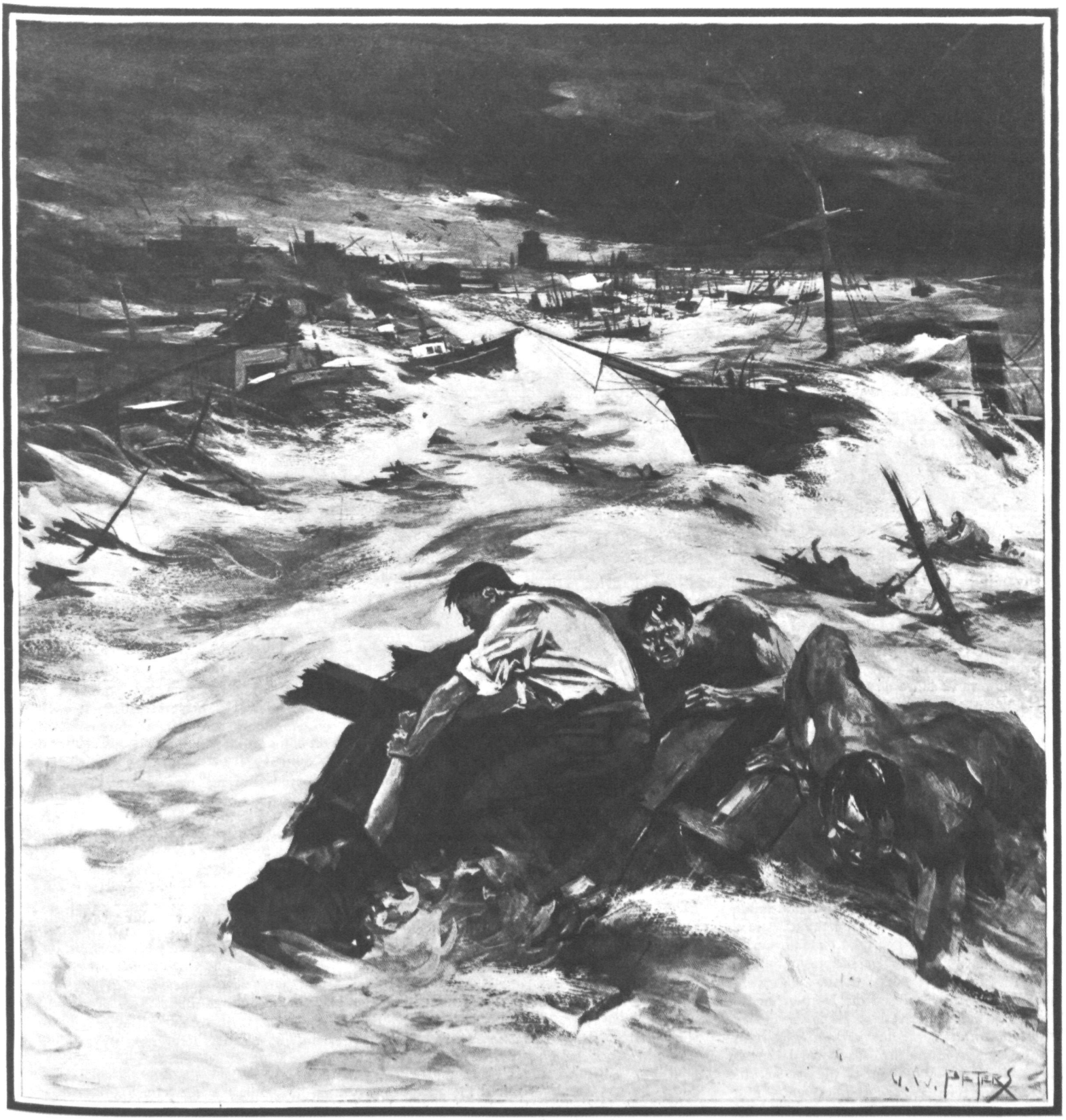
In the words of Clarence Ousley, editor of the *Tribune*, Galveston was "a city of splendid homes and broad clean streets; a city of oleanders and roses and palms; a city of the finest churches, school buildings, and benevolent institutions in the South; a thriving port. . . ; a seaside resort, with hundreds of bathers at play in the safest and most delightful surf in the world; a city of great wealth and large charity."

That was on Saturday, September 8, 1900.

On Sunday, September 9, Galveston was "a city of wrecked homes and streets choked with debris sandwiched with six thousand corpses; a city . . . with the slime of the ocean on every spot and in every house; a city with only three churches standing, not a school building or benevolent institution habitable; a port with shipping stranded and wrecked many miles from the moorings . . . ocean-going vessels sent crashing through railroad bridges or driven high on to shore and shallow; a wide, white beach and a rolling surf three hundred feet inward from the former water line . . . lapping an area of total destruction four blocks deep and three miles long. . .; a city whose very cemeteries had been emptied of their dead



Galveston, 1900. The shading shows the area of total destruction. The line shows the present sea wall. Except for a narrow beach, most of the area south of the line was scoured away by the storm.



THE DESTRUCTION OF GALVESTON.

DRAWN BY G. W. PETERS FROM TELEGRAPHIC REPORTS.

Photo: American Red Cross

Photo: The Rosenberg Library

St. Mary's Orphanage before the hurricane.

as if to receive new tenants."

Ironically, physical geographers had said that because of the long, gentle slope of the adjacent sea bottom, Galveston was safe from the full fury of tropical storms. And experience seemed to support their claim. Although Galveston had been hit fairly hard by major storms in the past—particularly in 1875 and 1886— loss of life had been very small compared to that of other Texas Gulf Coast communities like the town of Indianola, which had been totally destroyed in 1886 and never rebuilt.

The storm that was to prove the geographers wrong about Galveston's immunity was born about 4,000 miles away, over the tropical Atlantic west of the Cape Verde Islands on about the 27th of August.

The disturbance moved to the west-northwest, gradually gaining size and strength. By the 30th, it was generating thunderstorms in the Windward and Leeward Islands. On the 31th, the storm center passed just south of Puerto Rico, and, early Sunday morning, September 2, had crossed the Dominican Republic and Haiti.

On the 3rd and 4th, the still-growing tropical storm curved northwestward and crossed Cuba, heading for the Gulf of Mexico and the long, unprotected Gulf Coast. About 4 p.m. on the 4th, the Weather Bureau in Washington, D.C., issued its first telegraph advisory: "Tropical storm disturbance moving northward over Cuba." The message was received and distributed by Isaac Cline, chief of Galveston's Weather Bureau office.

On Wednesday, September 5, as it raked the Florida Keys, the tropical storm became a full-blown hurricane. At 10:20 a.m., Cline received a second advisory, which centered the storm near Key West.

The steamer Louisiana encountered the hurricane on Thursday the 6th, passing through the eye of the storm some 600 miles east-southeast of Galveston at about 1 p.m. The ship's barometer read 28.75. The captain estimated winds at more than 100 mph.

At 10:30 a.m. on Friday the 7th, Cline received notice that storm warnings previously issued for the eastern Gulf and the South Atlantic seaboard had been extended to include Galveston. That same afternoon, Captain J. W. Simmons of the steamer Pensacola, which was enroute from Galveston to its namesake city, watched as the ship's barometer fell to a low of 28.55. In 800 trips across the Gulf, Simmons had never seen the glass that low before. He dropped the ship's anchor, and the Pensacola hove to, struggling to stay afloat in towering seas.

Back in Galveston, the temperature was in the 80's, the sky was overcast, and a heavy swell was rolling in from the southeast. Crashing waves would soon drive bathers from the warm Gulf waters.

The swell increased during the night. By 4 a.m., several inches of sea water covered streets up to four blocks in from the beach on the Gulf side of the city. By 5 o'clock, Cline was on the beach to observe the tide, which was already 4½ feet above normal, despite a 15 to 17 mph north wind. Blowing offshore against the incoming water, a north wind should have caused a low tide at Galveston.

By daylight Saturday morning, Cline was worried. He hitched up his horse and cart and drove up and down the beach warning homeowners to move to higher ground and vacationers to go home. Many visitors followed his advice, but most natives were not particularly alarmed; they had seen flooding before. Indeed, most of the buildings in Galveston were raised several feet off the ground, to a level above the storm tide "overflow" that had washed across the island in 1875, the highest water level previously recorded.

Many early-rising Galvestonians even went down to the beach to watch the thundering surf crashing further and further inland. Already, the breakers had smashed several beachside buildings and destroyed a streetcar trestle.

By 7:45 a.m., it was raining. As the morning progressed, people living in lightly built houses near the beach moved to more substantial buildings nearby, or visited relatives living on higher ground to await the end of the overflow.

At 10:10 a.m., the Weather Bureau in Washington telegraphed that the storm center was now expected to pass west of the city, which would put Galveston in the dangerous right semicircle of the storm. There the winds would be stronger, and the storm tide would be higher. It also exposed the city and its inhabitants to the threat of a devastating hurricane wave.

By noon, the wind was blowing out of the northeast at more than 30 mph and increasing steadily. The barometer was dropping rapidly, and heavy rain was falling. The Gulf was now 3 to 5 feet deep in many streets near the beach in the eastern and southern sections of the city. Galvestonians coming home for lunch had to wade through water up to their waists and sometimes their chins to reach their houses.

At about this time, a number of lightly constructed cottages near the beach in the eastern end of the city were washed off their foundations and began to break up. The wagon bridge and train trestles connecting Galveston to the mainland were now submerged under the ris-

ing waters of the bay, which were flooding inland over the wharves along the northern side of the city. It was too late to get off the island. An hour later, about three-quarters of a mile inland, a baby tumbled through an open window and drowned in a flooded yard.

Shortly after 2 p.m., an artilleryman at Fort Crockett (on the beach in the western end of the city) was swept away by high water and drowned. More than 30 other soldiers abandoned their temporary wood-and-tarpaper barracks to move inland to a safer shelter. Three drowned in the attempt, a score more would die later.

By 2:30 p.m., the wind was blowing from the northeast at 42 mph, and the rain was "exceptionally heavy." Cline drove to the bay and the Gulf to assess the situation, then added "Gulf rising rapidly; half the city now under water" to the special weather observation he ordered sent to Washington. He also reported that the city was going under water fast, and that "great loss of life must result."

That was the last message to get out of Galveston. Cline, who had been on duty since 4 a.m., waded home to lunch.

Meanwhile, the temporary barracks at Fort Crockett collapsed on 12 soldiers who had stayed behind. Seven were killed; the others escaped by clinging to floating debris—an experience soon to be shared by many Galvestonians.

By 4 p.m., the wind had reached full hurricane force. Walter Fisher left the downtown drugstore where he worked to go home to his family. After struggling some distance through flooded streets, he became exhausted. Some men pulled him from the water and took him inside a house. After catching his breath, however, he was determined to go on.

He told the men, "If anything happens to me, tell my wife I tried to reach her." He died on his way home. His wife, Lillie, and their three children—John, Walter, Jr., and Annie—were killed later, when their house was wrecked.

Sometime between 4 and 5 p.m., the waters of the bay met those of the Gulf, and the entire city was submerged. By 5:15, the wind was blowing at 84 mph with gusts to 100 mph, and the wind gage had blown away. The wind was rolling up tin roofs and toppling telephone poles throughout the city. In the business district, large chunks of masonry were crashing into the flooded streets. Near the beach, many homes were being pounded to pieces by wind, water, and racing debris.

Joseph Cline, a 29-year old bachelor who also worked for the Weather Bureau, struggled through deep water to reach his brother Isaac's well-built home near the beach at abount 5:30 p.m. The brothers discussed moving to the center of the city, but people in the streets were being killed by flying slate and timbers from disintegrating houses, or being pinned under water by whirling wreckage and drowned.

The water, racing rapidly from east to west, continued to rise steadily until about 6:30, when it suddenly rose 4 feet. Isaac Cline was standing at his elevated front door in 8 inches of water; suddenly the water was above his waist. The Gulf was now 10 feet above the street, which was 5.2 feet above sea level. During the next hour, the water rose another 5 feet, forcing the occupants up to the second floor.

By 7 p.m., it was dark, and the wind was howling at an estimated velocity of 120 mph or more. Waterborne wreckage of other houses and a railroad trestle ¼-mile long were pounding against the east side of Cline's house like battering rams. At 7:30, the wind shifted to the east, blowing "with greater fury than before," and the house fell. It carried with it about 50 people, including whole families who had sought shelter there and the contractor who built the house.

As the house capsized, Joseph Cline grabbed the hands of his brother's older girls, 12-year-old Allie May, and 11-year-old Rosemary and jumped through a second story window. When the house rose to float on the flood water, the three were alone on the top side.

Isaac Cline, his wife, Cora May, and his youngest daughter, 6-year-old Esther Ballew, were trapped and carried under when the house rolled over. Cline lost consciousness. When he awoke, he was above water, and Esther was nearby. His wife was gone.

A few minutes later, Cline spotted his brother and his other two children and joined them. For the next several hours, the survivors scrambled from one piece of wreckage to another as the house broke up. The rain fell in torrents, and the roaring wind hurled timbers and other missiles past their heads. Whenever possible, the two brothers huddled with their backs to the wind and the children in front of them, holding planks behind their backs to ward off the flying debris that killed so many others that dark night. Even with this protection, they sometimes were struck by heavy debris and knocked into the racing water.

The Clines probably were carried out to sea, then back to the island, as the wind shifted first to southeast, then to south. About 10:30 p.m., the wreckage they were clinging to grounded at 28th street and Avenue P, a scant 300 yards from the site of the Cline house. The exhausted survivors climbed over mounds of wreckage to a still-standing 2-story house and crawled in through an upstairs window.

Attorney Clarence Howth's house was on Avenue P between 19th and 20 streets, only 3 blocks from the beach. His wife had given birth to their first child only the night before. Her father and brother were also in the house, as were a nurse and a maid.

About 6 p.m., the wind ripped off shutters and smashed windows on the east side of the house, while a number of nearby homes collapsed. Later, a 4-foot hurricane wave smashed in the side of the house. Howth and the others carried the new mother and baby to the attic, presumably the safest location. Soon however, the house went down. Howth struggled to the surface, but was washed down the beach in the racing torrent. He never saw any of the others again.

Henry Decie and his family lived 8½ miles down the island from the city. When the storm threatened their home, they moved to the house of Willie Raine, a neighbor. Some time later, the water suddenly rose 4 or 5 feet and lifted the house off its blocks.

"My wife and I were sitting on the foot of one of the beds . . . . We felt the house quiver, and my wife threw her arms around my neck and kissed me and said, 'Goodby; we are gone.' Just then the house crushed in, and we struggled hard to get out. My baby boy was in my arms a corpse, having been killed by a falling timber. I looked around and discovered that my wife was gone . . . . Catching a piece of scantling, I held on to it and was carried thirty miles across the bay, landing near the mouth of Cow Bayou."

The rambling wooden buildings of St. Mary's Orphanage stood on the beach 3 miles west of the city. They housed 10 Roman Catholic Sisters of the Incarnate Word, 93 orphans, and a workman.

By 10 o'clock Saturday morning, the water was already 3 feet deep. Later, as the storm worsened, the sisters took the children to the chapel on the first floor of the girl's building. They stayed there praying until rapidly rising water drove them to the second floor. From there they watched the boys' building break up in the storm. About an hour later—between 7 and 9 p.m.—the roof of their own building collapsed. With death threatening, the sisters tied the children together in groups, then to themselves, attaching the ropes to their waists.

Only a few scattered bricks from the foundation marked the site of the orphange after the storm. Ninety bodies were found nearby, including those of two of the sisters. The bodies of two other nuns, Sisters Raphael and Genevieve, were found at Texas City, on the mainland. Six more were found elsewhere on the island and mainland. One nun still had nine small children tied to her body; another was holding a child in each arm.

Only three orphans, all boys, survived the storm. Somehow they got out of the building and onto an uprooted tree sweeping by on the surging water.

The wind and water did not win all the battles. In the western part of the city, a carpenter's home sheltered some 50 people. As the building creaked and swayed and threatened to collapse, the owner drove the occupants to brace and bar walls, windows, and doors. They fought the storm for 6 hours. They were aided in their struggle by a telephone pole which fell nearby, wrapping its wires around the house and helping to hold it together and in place. One occupant died when he left to seek a safer refuge.

The Ursuline Convent and Academy provided shelter for almost 1,000 storm victims. Occupying 4 city blocks (Avenues N ot O and Rosenberg Avenue to 27th Street), the grounds were surrounded by a massive, 10-foot brick wall. The wall was destroyed by the storm, which washed debris from demolished homes—and their occupants—into the convent yard.

People were plucked from treetops and from roofs and wreckage with long poles and ropes and pulled into the convent. Family members torn from each others' arms by the storm were reunited in the convent yard. And four women gave birth in nuns' cells.

When her home went down, Mrs. William Henry Heideman, who was pregnant, was separated from her husband and 3-year old son and swept away on a roof from a wrecked cottage. The roof struck some other debris, and Mrs. Heideman was hurled off, landing in

a steamer trunk bobbing by on the surging water. The trunk hurtled along, bumping against driftwood and debris, until it smashed against the walls of the Ursuline convent and was pulled inside. William Henry Heideman, Jr., was born a few hours later.

While the sisters were attending to mother and child, a young man was fighting for his life in the convent yard. As he battled wind and water to cling to a swaying tree, he heard the cry of a child nearby. Reaching out, he plucked a little boy from the water. The man in the tree was Mrs. Heideman's brother, the child was her lost son. A rescue party from the convent brought the young man and his nephew into building, where they were reunited with Mrs. Heideman.

James Irwin and his wife were also reunited at the convent. Mr. Irwin was naked when rescued. The only dry clothing in the convent was a nun's habit. Mr. Irwin donned the religious garb, then spent the rest of the night helping others. After the storm subsided, he left the convent dressed as a Sister of Charity.

John Hopkins was superintendent of Galveston's public schools and lived near the central business district. As the water rose Saturday evening, he chopped holes in the floor so the water could come in and hold down the house, rather than lift it. Then he drank a bottle of beer and went upstairs to bed. He fell asleep almost instantly and slept soundly through the storm.

As he slept, the hurricane wreaked havoc on the harbor area and wharves on the north side of the city, tossing ocean liners around like corks. The British steamship Roma was hurled broadside through the remains of the three railroad bridges connecting Galveston Island to the mainland, then grounded in the mud.

Another British ship, the Taunton, was carried across nearby Pelican Island, "up the bay, along the shallows, far up where ocean vessel never went before and probably never will go again . . . until she was dashed head on to a bank thirty feet high, called Cedar Point, twenty-two miles from deep water!"

At least 10 other steamships were either battered in their berths or torn away and stranded in shallow water.

Galveston Island was not the storm's only victim. Homes and towns were ravaged all along the low Texas coast. The following account is from the St. Louis *Globe Democrat* and concerns a Houston family on holiday at a beach resort:

"Mr. McIlhenny was rescued alive, and is completely prostrated. He said the water came up so rapidly that he and his family and Mrs. Lucy (his married daughter) and her children sought safety on the roof. He had his little son, Haven, in his arms, and the other children were strapped together. It was not long before a heavy piece of timber struck Haven, killing him. Young Rice [a 5-year-old visitor] was washed off the roof and drowned.

"Mrs. Lucy's oldest child was next killed by a piece of timber, and the younger one was drowned. Then Mrs. Lucy was washed off and drowned, thus leaving Mr. and Mrs. McIlhenny the only occupants on the roof. Finally the roof blew off the house, and as it fell into the water it was broken in twain. Mrs. McIlhenny remaining on one half and Mr. McIlhenny on the other. The portion of the roof to which Mrs. McIlhenny clung turned over, and this was the last seen of her.

"Thus in a very brief space of time Mr. McIlhenny witnessed the loss of his family, one by one. He held to his side of the roof, so distracted in mind as to care little where or how it drifted . . . . "

Lucas Terrace, a well-built, 3-story brick apartment house, stood near Galveston's east end. One wing faced east across sand dunes, the other south, onto Broadway. One of its occupants, Daisy Thorne, a young school teacher, lived in a 2-story flat with her mother, a sister (who was out of town), a brother, and an aunt. By 4 p.m. Saturday, Lucas Terrace was the only building in the neighborhood still standing. Survivors of nearby cottages and other lighter buildings swept away by the storm sought shelter in its massive wings. By 5 p.m., 22 people were jammed in Daisy Thorne's tiny (12′×12′) back bedroom on the second floor of the south wing.

Sometime after 5, wreckage from Fort Point on the eastern tip of the island began pounding against and finally demolished the east wing. One man was thrown through a window and survived; all the other occupants perished.

In Daisy's bedroom, most of the ceiling was gone after 6 p.m., and breaking waves poured water in over the tops of the walls, drenching the people inside. Their ordeal was to last 4 more hours, with each wave threatening the room's collapse.

Some time around 10:30 p.m., the water began to fall. Daisy Thorne's bedroom was the only one of Lucas Terrace's 64 rooms still more or less intact. The walls of the apartment below had fallen, but debris lodged in the shell helped support the upstairs bedroom. Still fearing the room's collapse, 22 shaken survivors climbed out a window onto a pile of debris and, shivering with cold, awaited the dawn.

Later, as they picked their way over debris piled several stories high, they heard cries for help from people trapped in the wreckage. They tried to help, but it was hopeless. It would take months to remove the debris.

If the night had been terrifying, the dawn brought horror. In the area of total destruction, all that remained of thousands of homes and of many of the people who had lived or sought shelter in them was a 3-mile long mound of wreckage jammed with bodies forming a semicircle around the business district. Outside this arc not a building was standing, not a street was outlined. Wind and water had restored the land to primal beach.

Many of the bodies and many survivors were naked or near-naked, their clothes torn or ripped off by protruding nails, jagged pieces

After the hurricane, Galvestonians built a sea wall and raised the level of the City behind it. Before the storm, the City lay almost level with the sea.

Photo: The Rosenberg Library

Photo: The Rosenberg Library

of wood, broken glass, and flying debris of all descriptions. Hundreds of whole families had perished, and almost every family had lost at least one member. An estimated 8,000 to 10,000 survivors were homeless. The bay was clogged with hundreds of human bodies, and the corpses of cows, horses, chickens, and dogs were everywhere.

By Monday morning, undertaking parlors and temporary morgues were jammed with bodies. In most cases, identification was impossible. As more and more bodies were uncovered, the survivors began to realize the scope of the disaster. Regular burial was impossible. A mass solution was needed, and burial at sea was suggested.

By Monday night, about 700 bodies had been hauled to the 12th street wharf, put on barges, and taken out to sea. The corpses were weighted and thrown into the Gulf, but many made a grisly return to the beach with the incoming tide.

Sunday and Monday had been hot. The health of the living now demanded immediate action. On-the-spot burial or burning were the most practical solutions. On Tuesday Galveston became a city of funeral pyres. A dark pall of smoke hung over the island for weeks as the grim work continued.

On October 3, almost a month after the hurricane, the body of Cora May Cline, identified by her engagement ring, was discovered under the wreckage that had carried her husband and children to safety. She was buried in Galveston Cemetery.

While the tasks of burning or burying the dead, removing debris, and disinfecting the city went on, other survivors worked to repair or restore the water supply, telegraph and telephone lines, electric lights, and railroad and streetcar service. Sympathy, supplies, and money poured in from the rest of the nation and from around the world. President McKinley made rations and tents available. William Randolph Hearst sent relief trains. Clara Barton came to Galveston to work with the relief committee. And the people of Johnstown, Pa., who had lost 2,200 of their own in the infamous flood of 1889, took up a special collection for the survivors of the Galveston disaster.

By Wednesday, 4 days after the storm, the first grocery store was open for business. The next day, telegraph service to the mainland was restored, and, for the first time, many survivors were able to send messages to frantic friends and relatives. Early Friday morning, a railroad bridge to the mainland was completed; the first relief train chugged into Galveston at 6:20 a.m. By Saturday, at least one mule-drawn streetcar was operating, and electricity had been restored to a few homes and stores.

Galvestonians learned from the hurricane that they needed a seawall. Flood waters of up to 20 feet, perhaps higher, had swept the eastern and southern parts of the city seaward of the barricade of wrecked houses and debris. This barrier apparently had acted as a breakwater, absorbing the terrible destructive force of the waves and catching wreckage before it could flatten buildings behind it, where most of the survivors had taken refuge.

So Galveston built a seawall. The first pile was driven on Oct. 27, 1902; the wall was completed July 29, 1904. It was 3.3 miles long and rose 17 feet above mean low tide. A solid 16 feet wide at the base and 5 feet across at the top, it was strengthened against undermining and erosion by a loose layer of rough granite blocks that extended 27 feet seaward.

Photo: Library of Congress

The ruins of Sacred Heart Church.

Galvestonians also decided to raise the level of the city by pumping in sand from the floor of the Gulf. This meant raising 2,146 buildings—every house, school, church, and store—as well as waterpipes, fire hydrants, streetcar tracks, trees, shrubs, flowers—in short, everything. When this was accomplished, 14 million cubic yards of sand were pumped in under the raised structures from a 20-foot-deep canal dug lengthwise through the city behind the seawall. The street level was raised to 17 feet at the seawall, sloping to 10 feet at Broadway. The massive undertaking was not finished until July, 1910.

On the night of August 16, 1915, the city was tested by another great hurricane that followed closely the track of the 1900 storm. It brought winds of 92 mph with gusts to 120 mph, 10- to 14-foot storm tides, and 21-foot waves. This time, however, thanks to the seawall and the raising of the grade, fewer than a dozen people were killed in the city.

The seawall has been extended several times since the first section was built, and grade raising has continued as the city has grown. Galveston learned its lesson well. Unfortunately, other U.S. coastal communities may someday have to learn the same lesson.

The 1900 Galveston hurricane killed about 6,000 people in the city, at least 2,000 more elsewhere; some estimates total as high as 12,000. Yet it is not the most severe hurricane ever to hit the United States; there have since been a dozen others of approximately equal severity and two that were more intense—a hurricane that struck the Florida Keys in 1935 and Hurricane Camille, which hit the Gulf Coast in 1969.

Today, tens of millions of Americans live in hurricane-vulnerable coastal communities from Maine to Texas. In the summer, the seaside population is several times larger. Most of these people have never seen a hurricane; they have no idea of its power and potential for destruction. And, as at Galveston, they live and play on or near beach and tidal areas that could be swept clean by hurricane tides and waves. Moreover, many of these places are connected to the interior by only one or two narrow roads.

Should a hurricane strike a major beach resort area during the summer season, the potential for catastrophe is unthinkable. □

After Galveston:

Could It Happen Again?

By CHARLES G. THOMAS

Horror stories abound in the hurricane business.

In 1919, a great storm brushed the Florida Keys, roared across the Gulf of Mexico and slammed into south Texas, killing 287 persons on land and more than 500 in ships lost at sea.

Hurricane winds in 1928 literally blew the rain-swollen waters of Florida's Lake Okeechobee out of its banks and into populated areas causing most of the storm's 1,836 casualties.

The "Labor Day Storm" of 1935, an incredibly violent hurricane with winds estimated between 150 and 200 miles per hour, ravaged the entire west coast of Florida killing more than 400 persons.

Three years later a hurricane's winds and storm surge killed 600 persons and caused widespread damage throughout New England when it came ashore on the Connecticut coast.

In the past 30 years, Carol and Hazel in 1954, Diane in 1955, Audrey in 1957, Donna in 1960, Carla in 1961, Betsy in 1965, and Agnes in 1972 are among the most ill-remembered killer storms.

And then—10 years ago this August—there was Camille, which struck the Gulf Coast at Pass Christian, Miss., and went on to cause deadly flash floods in Virginia.

Camille was something else. In the words of a report made shortly after the storm:

"No hurricane as intense as this had ever struck the mainland of the United States. The need to remove everyone from the tidal beaches was urgent and, in at least one case, arrests were made in a desperate move to save lives. By official estimate 81,000 people moved to safety. The remainder were fully warned but some stubbornly remained: the curious, the unbelievers, the survivors of past storms, and those few who could not bring themselves to abandon all they owned.

"By 7 p.m. Sunday, the (National Weather Service) office at Boothville, La.—about 60 miles southeast of New Orleans—was reporting wind gusts of 107 miles per hour. An offshore drilling rig was raked by gusts estimated to be about 170 miles per hour. On the Mississippi shore, as the evening progressed the wind increased until by 10 p.m. its sound was a continuous roar. In the unbelievable chaos of windblown debris, the dreadful tide moved on the land. Sweeping inshore, it was an irresistible force topped by crashing waves that demolished everything in its path. Ocean-going vessels and small craft alike were swept inland and deposited among the remnants of buildings. Eyewitnesses reported that the deluge remained ashore very briefly—only for some 20-30 minutes—sucking back into the Gulf of Mexico with such speed that it carried much of its appalling burden with it."

The final death toll from Camille is officially listed at 256. Nearly 70 persons are still carried in statistics tables as "missing." Grim figures, indeed, but it could have been much worse.

According to the Federal survey team that evaluated the hurricane warning service and related activities during the Camille emergency, the storm's arrival along the coast was forecast about 15 hours before landfall, permitting a massive evacuation of the hurricane-conscious population of the area. "This 15-hour warning," the team's report said, "taken with the high level of individual and community preparedness for such emergencies, saved an estimated 50,000 lives."

Damage from Camille reached a billion modern-economy dollars—at the time easily the most costly hurricane in history. But Camille only held the record three years.

Agnes, the first Atlantic hurricane of the 1972 season, caused what has been termed among the greatest natural disasters ever to befall this Nation, and yet it could barely sustain its hurricane-force winds. When it crossed the coast near Panama City, Fla., on June 19, 1972, Agnes had degenerated to a tropical storm. Its highest windspeed over land was 56 m.p.h. in gusts. But Agnes was very big and very wet.

The storm moved over Georgia and out into the Atlantic, up the coast to New York, and westward over New York and Pennsylvania. Carrying moisture from both the Gulf and Atlantic, Agnes regenerated, producing incredible amounts of rain, and caused rivers and streams from the Carolinas to New York to rise to record or near-record stages. A record $2 billion in property damage was caused by Agnes' floods and flash floods, and 118 persons were killed.

Since Agnes, three hurricanes stand out because of their devastating effect on the U.S. mainland. Carmen in 1974 struck Louisiana, causing considerable damage to the sugar cane crop. In 1975, Eloise's storm surge and winds caused great damage to structures along the coastal strip from Fort Walton Beach to Panama City on the Florida panhandle. Belle in 1976 caused quite a scare as it headed up the east coast toward the highly populated region between Washington and Boston. A half-million persons were evacuated from coastal areas as the storm caused considerable inland stream and road flooding and damaged Northeast crops.

But these three storms, as damaging as they were, caused only 10 deaths among them, a fact attributable to timely National Weather Service warnings and a large amount of luck. And luck may be running out.

It's been 10 years since Camille and a major loss of life from a hurricane, and National Weather Service forecasters are growing apprehensive about public apathy.

Indications are that nearly eight out of 10 people who live on the hurricane-prone Gulf and Atlantic coasts have never experienced a major storm. Those who have been through a mild one or have seen only the fringe effects of a major one will tend to underestimate the lethal effects of a hurricane, forecasters fear.

So each year during the June through November "hurricane season", the National Weather Service conducts a campaign to inform the public of the Damoclean threat of a major storm's striking the United States in one of the scores of areas where mushrooming population growth make a tragedy of the Galveston magnitude a terrible but real possibility.

It's a grim message, but it's worth repeating.

Hurricane forecasters strive to provide at least 12 daylight hours of warning time for evacuation, but even this may not be enough

time unless the residents of a threatened area are covered by an effective disaster emergency plan prepared and rehearsed by concerned local and state officials. Most important, individuals must acknowledge that living in on the Nation's coast today involves a certain amount of real danger when a hurricane threatens. Every coastal resident must make a personal commitment to the successful development of a community hurricane preparedness plan.

Somewhere along our coastline—maybe this year, maybe next—a severe hurricane is going to strike a heavily populated area. Be ready, the National Weather Service says. □

HURRICANES

Deadliest ten in U.S. (20th Century)	
Galveston 1900	6,000
Okeechobee 1928	1,836
Keys & Texas 1919	600-900*
New England 1938	600
Florida Keys 1935	408
Audrey 1957	390
Atlantic Coast 1944	390
Grand Isle, La. 1909	350
New Orleans, La. 1915	275
Galveston 1915	275

*Many deaths were from ships lost at sea.

Sea Grant and NWS share a vital task

Disaster Preparedness For Floridians

By THOMAS M. LEAHY*

Speaking to a meeting of Florida marina and boatyard operators, Dr. Neil Frank, director of the National Hurricane Center in Miami, warned of unpleasant things to come.

"We have a people problem," Frank told the group. "In the sixties we had a 10 percent increase in our national population but a 43 percent increase in the number of people living along beachfronts. We have brand-new construction from Texas to Maine. Tied in with an increase in population are people coming to Florida today for sunshine, surf, and fishing. We have population concentrations today that I'm not sure we know what to do with. I'm not sure we can evacuate places where we have such large groups of people today."

No one wants to contemplate what might happen if Florida experiences a return to the 1940's, the decade when hurricanes were most prevalent, but the State is vulnerable and the possibility does exist. The Florida Sea Grant Marine Advisory Program (FMAP) is in the forefront of those who are doing something about it.

That "something" is an expansion in the scope of the marine advisory services to include natural disaster preparedness, an effort that may ultimately result in minimizing destruction of property and saving lives. Already results from this effort have spilled over into other areas, notably agriculture, which has long been a priority of the Cooperative Extension Service.

FMAP, already heavily involved in commercial fishing and seafood processing, sport fishing, marine recreation, coastal engineering, and marine education, added this extra dimension with a mobility exchange assignment under the Inter-governmental Personnel Act of 1970.

This brought Robert Carrodus from his post as a supervisor of graphics at NOAA's Atlantic Oceanographic and Meteorological Lab-

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** Thomas M. Leahy is an editor with Florida Sea Grant and the Marine Advisory Program*

Photo: Benard Brandt

Folk Fair at St. Petersburg (right) draws large crowd. Water spout (opposite page) heads toward high-rise condominiums in Ft. Lauderdale.

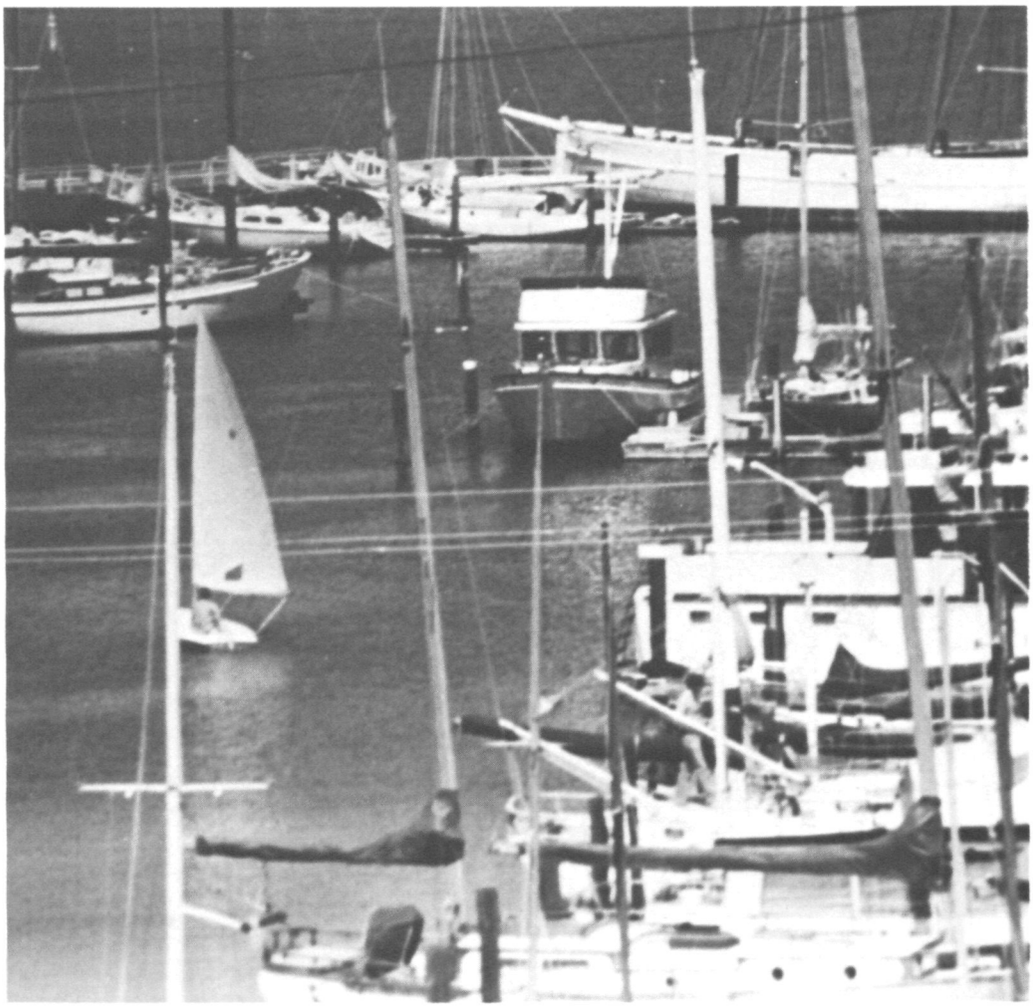


Photo: Ron Brandt

Photo: Billie Lowry

Left, fishing and boating provide recreation for thousand of Florida residents who now own nearly 500,000 registered boats in the state. Above, top, Pat Jamerson points out her area of responsibility to co-workers. Above, bottom, members of the Florida Marine Patrol.

oratories in Miami to the University of Florida in Gainesville.

In Gainesville, Carrodus became a special assistant to the coordinator of the Marine Advisory Program, charged with heading the Emergency Preparedness and Awareness Pilot Project, a new and rapidly expanding program of the Florida Cooperative Extension Service.

Carrodus' assignment was the first such action under the Inter-governmental Personnel Act, a one-way exchange between NOAA and the Florida Sea Grant Marine Advisory Program, and it has been called an unqualified success by Robert Shephard, Program Manager for NOAA's National Marine Advisory Service.

"Florida was chosen as the site of our pilot project exchange for several reasons," Shephard said. "The long coastline represents an immense exposure area to coastal storms, the ocean is very important to the State's economy, and the Marine Advisory Program there is emerging as in important element of the Florida Sea Grant College and the Cooperative Extension Service."

From his crowded office on the University of Florida campus, Dr. Marion Clarke, assistant dean for marine programs in the Cooperative Extension Service and FMAP coordinator, talked about the rapid growth of marine advisory services in Florida, superimposed on the very substantial and continuing population growth of the State.

"Florida is a big state," he said, "with over 58,000 square miles of land area, 1,350 miles of coastline, and a shoreline of nearly 8,500 miles. There are 10 deep water ports, 50 estuaries, 50 inlets and a lengthy intercoastal waterway."

To serve this extensive area and the rapidly expanding population living there, Clarke now has eight marine advisory agents in the field with a ninth one due shortly.

"These agents work out of county extension offices and cover every coastal county," he continued. "Some of them have six or eight counties to cover. But Florida's 39 coastal counties, 12 east coast and 14 northwest counties are showing extensive growth patterns. We project a marine agent network of around 21 by 1990."

Clarke said that the assignment of Carrodus added a fifth university-based specialist to the FMAP staff and indicated that he has the responsibility for implementing an overall educational program for natural hazard awareness in coastal areas and fostering understanding of natural systems affecting weather and the related environmental, social, and economic impacts, an area in which FMAP had had only a minimum of involvement previously.

There were 54 hurricanes between 1900 and 1975, he said, the last one hitting the northwest coast between Fort Walton Beach and Panama City in September 1975, inflicting millions of dollars in damage. But since that time, the state's population has increased by nearly 1,800,000 residents with an estimated 1979 population of over nine million, many of whom have never experienced a hurricane, and, in fact, appear to be quite apathetic about them. To compound the problem, much of the population increase represents persons of retirement age who tend to locate in the already heavily populated coastal counties. Coming from Northern States where severe winters are common, they often seem to reflect the philosophy, "I've been through snow storms and blizzards—a hurricane couldn't be much worse."

"There is no point in the State of Florida that is more than 70 miles from salt water," Clarke said, "and it is estimated that 78 percent of all residents live on or near the coast."

Carrodus views his role as that of a catalyst in promoting and carrying out grass roots delivery of NOAA information functions and programs to improve emergency preparedness and awareness of natural disasters among this mass of people and State and local officials, especially those with coastal exposure.

"This effort is critical to the well-being of the coastal residents and visitors to Florida," Carrodus said, "and will demonstrate the capacity of the National Sea Grant Office, NOAA, National Weather Service (NWS), Florida Sea Grant, FMAP, and the Coopera-

With one of the fastest growing populations in the Nation, Florida sees a large percentage of its residents settle in coastal areas like Miami.

tive Extension Service to assist Civil Defense with improvement of natural disaster education and preparedness in the State."

The educational programs include both formal and informal efforts, he said, and indicated that marine advisory agents are becoming increasingly involved in developing and implementing the programs. The expertise of Federal, State, and local agencies is utilized and the entire effort is coordinated with the NWS Regional office, the disaster preparedness staff and the staff of the National Hurricane Center as well as meteorologists in charge of the various weather stations. The program is also closely coordinated with the State Office of Civil Defense and office of Education in developing curriculums for all levels of the educational system.

"We think of hurricanes when we think of Florida," Carrodus said, "but Florida has its share of tornadoes, too. Recently we have had a lesson in just how destructive a tornado can be. Look at what happened in Wichita Falls, Texas. We don't ignore tornadoes. Last year nearly 68,000 persons participated in this program by attending hurricane and tornado workshops in 20 counties. The program has conducted tornado spotter workshops for law enforcement and Civil Defense officials in Gainesville and at various locations throughout the State."

As often happens when an effort is expended in one program there is a resulting spinoff in other areas. In this case Florida's huge agriculture industry received several advantages from the increased awareness program, according to Carrodus.

Swine, for example, are vulnerable to extremes of heat when being shipped to market and some die from too high a temperature and humidity. Now, as a result of the program, NOAA Weather Radio is furnishing hog farmers in the northern portion of the State a "comfort index" determined from a combination of temperature and dew point readings. From this they can determine when it should be safe to ship their hogs to market.

Another example was the suggestion that in the event of high water or tropical storms involving flooding the farmers should construct mounds of dirt in their pastures so that cattle can retreat to higher ground.

Another idea to assist farmers comes from the Hurricane Task Force Committee of the Florida Cooperative Extension Service, another part of the awareness program. Agronomists on the task force have developed methods for blanching soil that has experienced salt water intrusion and have also determined what plants could best be grown after salt has entered the soil.

The Weather Service also has benefited. Through efforts of FMAP and Walter Sitarz, a port meteorologist, the Florida Marine Patrol now sends weather observations directly to the local weather offices. Information includes wind velocity and direction, temperature, state of the sea, and cloud cover. This information has improved the accuracy of NWS marine forecasts. Private yachts which carry sophisticated weather gear are also tied into the reporting system and regularly furnish up-to-date information to weather offices for use in forecasts on NOAA weather radio. This equipment has proven useful in maintaining safety communication with vessels when marine bands fail, as well as making NOAA weather radio broadcasts more relevant to the needs of the listening public.

FMAP has published an advisory bulletin, "Boating Safety—Thunderstorms," written by Sitarz under the auspices of Florida Sea Grant College. In cooperation with the Dade County Marine Council, FMAP is also developing and holding boating safety seminars and workshops to improve boater knowledge and awareness of severe storms. In boating country like Florida, this is an important consideration. Nearly 500,000 boats are registered in the state—approximately one for every 19 residents—and this does not count those brought in by non-residents for sport fishing or recreation.

Carrodus, with two years remaining on his assignment, has planned a full schedule of activities to continue to improve the FMAP emergency preparedness and awareness project. He plans to establish citizen technical advisory committees composed of representatives from all agencies currently engaged in disaster preparedness, awareness, and education in the State.

Both he and Clarke emphasize that the overall objectives of the Florida emergency preparedness pilot project are to develop and implement educational programs and materials for public schools; developing and implementing an awareness program for Florida's coastal residents and visitors; assisting with local, regional and State emergency preparedness planning when appropriate; serving as public information liaison for the National Hurricane Center; providing support for public liaison with local weather stations; assisting with developing programs for NOAA weather radio; developing and implementing research to meet emergency preparedness needs of coastal publics; and developing and distributing materials relevant to program needs.

"We hope the findings of this pilot project may result in similar program efforts through Sea Grant and advisory service operations in other coastal States," Clarke said.

With the onset of the 1979 hurricane season the wisdom of choosing Florida as the site for the pilot project exchange becomes increasingly evident. Much has been done already to educate the public on ways to protect life and property. Much more remains to be done.

As Dr. Frank stated on another occasion, "if you decide to live on the coast of the State, hurricane awareness and preparedness is not really an option for you. It is a necessity." □

A marvel of Nature needs our protection

The Barrier Islands

By BRIAN GORMAN

Stretching along the coast of the United States from New England to Texas lies an irregular chain of long, narrow landforms made up of little more than endlessly shifting sands and fragile dune grasses.

They are barrier islands, a major defense for the mainland against assaults from wind and sea, acting as effectively as the most carefully designed manmade breakwaters.

Although physically separated from the mainland by marshes or open water, they are intimately tied to the shore as protectors of estuaries, wetlands, and river mouths. They are available as nurseries and refuges for fish, birds, and other wildlife, and as buffers against siltation, salt water, and currents. Yet they are individually so unstable and amorphous that virtually all of them are constantly changing size, shape and even position. Subjected to the fury of winter storms, floods, and winds, literally scores have appeared and disappeared over the past century. Even given their volatile nature, they are so vital to our coastlines that Federal and state planners are taking unprecedented steps to protect them.

Beyond their biological and geological function as a kind of arbiter between land and sea, barrier islands are a major source of wealth and prestige when they are the sites for cities such as Atlantic City, Galveston, and Miami Beach. At the same time, other relatively unspoiled islands such as those at Chincoteague, Va., and Cape Hatteras, N.C., can spark the kind of strong reaction in even the casual visitor that would warm the heart of a Thoreau.

Geologically, barrier islands are the infants of our coastal zone, having been formed only in the last five or six thousand years. Along the northeastern coast of the United States, from New York to Massachusetts, they owe their formation to the erosion of glacial deposits that were later dumped by the retreating ice sheets in long, narrow spits reaching out from the land. In some cases, such as Fire Island, N.Y., the spit has been breached by the ocean, breaking it free from the mainland and forming an island.

In other parts of the Atlantic, for example, North Carolina's Outer Banks, as the sea level rose, dune ridges along the mainland were cut off from the shore and became islands.

Geologists attribute a third mechanism of barrier island formation to an opposite effect:

the rising of previously submerged offshore shoal areas, likely the case with the landforms off the Mississippi coast. Still other islands were created by the deposition of river silts from deltas. Examples of these are found around Cape Romain, S.C., and at the mouth of the Mississippi.

As different as their geological origins may be, all barrier islands have one thing in common: a remarkable dynamism. Of course, all land structures are dynamic (Cole Porter noted that the Rockies may crumble and Gibraltar may tumble). But such changes take place so slowly that they are noticeable only over hundreds of years. Barrier islands, however, exhibit a physical evolution that is continuous and is readily apparent from one season to the next. In the face of a violent storm, the change can occur literally overnight.

Along the Atlantic coast, powerful winter north-easters regularly move vast quantities of sand from the beach to offshore sand bars. There a part of the island is, in effect, held in storage until the summer, when calmer seas transport the offshore sand back to the beach again. The effect can be dramatic. During the course of a single year, a barrier island may be halved in size, only to be doubled a few months later.

Even more dramatic than the offshore transport of sand is the wholesale migration of an entire island toward the land. As waves and wind drive sands over the top of an island, depositing it along the calmer landward side, it can undergo a virtual rollover as it moves landward. On some islands, for example, the remains of small forests are lapped by ocean waves. The forests had once been on the landward side of the island. While the trees remained in place, a stark marker of the protean quality of the sands, the island itself passed over them, leaving nothing now but stumps protruding from the ocean at low tide.

When the victim of such a migration is not trees, but people and their homes, the effect can be as tragic as it is dramatic. In the early 1900's, for example, there was a small town called Broadwater on Hog Island, Va. Today the remains of the town, like some poor man's Atlantis, lie several hundred yards out to sea, the victim of wind and surf and the natural dynamism of barrier islands.

In addition to wind and surf, another natural element relates to the transportation of barrier beach sand: littoral drift. As waves approach a beach from any angle but straight on, they break and then crash back to the sea at an angle. The result is that with every wave that comes ashore, a certain amount of sand is picked up from the beach, briefly washed out into the surf zone, and then returned some distance down the shore. The net effect of this continuous pushing in and washing out of countless grains of sand is a constant migration of the edge of the beach in the direction of the offshore current. A river of sand moves slowly down the island's far end, where it is

Isolated stretches of sandy beach or the sites of huge cities, barrier islands are ever-shifting, resilient natural breakwaters.

Photo: Kelsey Airview

The cost of overbuilding on a barrier island was paid on Nauset Beach, Cape Cod, when a winter storm hit in 1978

deposited, frequently causing a hook of land to grow out into the sea.

In many cases, the littoral drift doesn't end with deposition on the downdrift end of the barrier island, but continues across an inlet to be deposited on an adjacent island.

It would seem from this description that barrier islands are the Cheshire cats of the coastal zone, disappearing and reappearing, migrating first landward and then seaward, inviting whole communities (both human and animal) to come live on them and then slipping quietly into the sea. Yet, the very aspect of the islands that gives them their dynamism also makes them remarkably stable in a geologic and ecologic sense. As a system, barrier islands exhibit an amazing adaptability. They are flexible enough to absorb the titanic energies of the ocean and the atmosphere and to act as a self-repairing first line of defense for the mainland. In this role, they have become a highly productive habitat for a wide variety of terrestrial and marine plants and animals.

One factor against which barrier islands have no effective defense, however, is human intervention. It may appear ironic that a geologic formation that can withstand the onslaught of a hundred winter storms and continuous erosion by wind and current, can be thrown completely out of balance by dune buggies, summer cottages, and high-rise condominiums. Nevertheless, as countless Government officials,biologists, and home owners can attest, it is true.

Perhaps the greatest stress for a barrier island is as a home construction site, the use to which they are most frequently put. Dune ridges, which provide stability to the island by serving as a foundation for grasses, preclude that essential aspect of oceanfront lots: a view of the sea. Yet the dunes can be quickly and easily bulldozed, resulting in level sites and throwing open broad oceanic vistas.

While this may please the developer and entice the buyer, the removal of the dunes eliminates one of the island's most important benefits, defense against storms. Without dunes, which typically rise ten or 20 feet above sea level, wind-driven water from winter storms can easily wash over the island. If it is severe enough, the island may be breached, cutting it in two. Even without an overwash violent enough to breach the island, sufficient seawater can be driven across it to upset the saltwater balance of any wetlands on the mainland.

Nor do the wetlands behind the island, nursery for more than 90 percent of the commercial fish in some areas, present any special problem to developers. They are simply drained and filled, turning "useless" swamp into valuable real estate.

Finally, the natural erosion of littoral drift—one of the most serious impediments to home construction on a barrier island—can be contained. Groins and jetties can be constructed to stop the flow of sand and improve beachfront property. But like removing dunes or filling swamp, such action has substantial and expensive repercussions, that are not readily apparent. The shoreline on the downdrift side of the groin, no longer fed by a constant supply of sand from the littoral current, tends to erode. The solution traditionally has been simply to build another groin which in turn causes more erosion, and can lead eventually to the construction of as many as a dozen, each one trying to "correct" the damage done by the preceding one.

Plants and animals that have become dependent on the barrier islands' dynamism, in spite of the Spartan conditions under which they have evolved, exhibit a tenacity and adaption that seems to rival that of the beaches themselves. Swift recolonization is common. But, like the islands, careless treatment by humans can upset this delicate balance.

The salt meadow cordgrass that grows along the dunes and sand flats of North Carolina's Outer Banks is a case in point. The conditions under which it lives, thrives, in fact, can be described only as desperate. Subjected alternately to salt spray and drying sun, it is occasionally buried under a foot or more of sand, the result of sudden storms. Nevertheless, it returns, sending up green shoots throughout its growing season, and providing a natural anchor for the dunes. Yet it is no match for an overland vehicle. As few as two passes a day by a four-wheel-drive machine is sufficient to destroy a stand of cordgrass within a month. With it goes the major stabilizing factor for the dune on which it grows.

Nor is it simply a few species of plants and animals whose existence is threatened by careless development. At least as important as ruined nurseries, wildlife refuges, and the beaches themselves is the ironic fact that the people who build on the beaches can be exposed to storms and hurricanes from which the islands, now developed, can no longer protect them.

The future is not as bleak as it might seem, however. Many coastal states have recognized the threat that unrestricted human development poses both to barrier islands and to the persons who wish to enjoy them.

North Carolina, as far back as 1957, passed an ordinance that requires a permit before any removal of or damage to the Outer Banks sand dunes can take place. This includes the destruction of trees, grass, or other vegetation growing on the dunes.

Even greater protection to the barrier islands' shorelines and their associated wetlands occurred in 1970 with implementation of the State's Dredge and Fill Law. This law requires permits for any excavation or filling along any of North Carolina's 300 miles of shoreline or within its 2.3 million acres of marshlands and estuarine waters. This concern, backed by enforceable laws, was in part responsible for the Commerce Department's approval of North Carolina's Coastal Zone Management program in September 1978, making it the first Southern State to win such approval.

So enormous is the problem of barrier island erosion, and so expensive are attempts to stem it, that the National Park Service, after spending millions of dollars on erosion control along Cape Hatteras has come to what many consider to be a highly enlightened conclusion. With the help of geological studies, the Park Service determined that in some cases erosion—no matter what steps were taken—simply could not be halted for any appreciable period. As a result, Park Service policy is now generally to let natural forces take their course and not to try to replenish beaches.

Other States, many with assistance from NOAA's Office of Coastal Zone Management, have undertaken similiar efforts to protect and preserve those barrier islands that are still relatively undeveloped. Fifteen of the 17 East

and Gulf Coast states, for example, have set aside certain islands or parts of them as State parks or natural areas. Other States have established National Seashores within them. Seventy percent of Maryland's Atlantic coast, for example, is included as part of a National Seashore, as are three of Mississippi's five barrier islands.

Not surprisingly, most of the comprehensive barrier island preservation efforts are taking place in the State parks of the Southern and Gulf Coast states—South Carolina, Georgia, Florida, and Texas—whose islands have not been subjected to the same urban pressures and coastal development as their northern neighbors.

In addition to insuring that barrier island development will be carried out in the best interests of the island and the people who wish to enjoy it, cooperative State/Federal efforts are being made to learn more about their dynamics. Such knowledge can result in more scientifically based decisions about home construction, erosion, and the effect of nature and man on barrier islands' evolution.

As part of this effort, late in 1975, Georgia became the first State to have one of its barrier islands designated an estuarine sanctuary by the U.S. Department of Commerce, as part of NOAA's Estuarine Sanctuary Program. The sanctuary, located on Sapelo Island, has been set aside as a living laboratory to allow biologists, geologists, zoologists, chemists, and others to take an in-depth look at a pristine barrier island. Their work, carried out through the University of Georgia Marine Institute, is leading to a better understanding of the biological and physical complexities of these important structures.

Georgia also is providing ample evidence of the ability of local governments to determine what will or will not happen on barrier islands. Glynn County, for example, has some of the strictest coastal protection ordinances in the Nation. County regulations require that all permanent structures must be mounted on pilings at least 14 feet above the high tide mark. In addition, nothing can be built closer to the barrier island's first stable dune than 40 feet. The result of such "stormproofing" measures is that summer home construction has been made more compatible with the natural forces that can assault a barrier island, and the threat of the wholesale destruction of a vacation community by a violent storm has been minimized.

Other States have taken even stronger action. Rhode Island's coastal zone management program, which received Department of Commerce approval in May 1978, flatly forbids development on any of the State's 18 undeveloped barrier beaches. The prohibition, recently upheld by the Rhode Island Supreme Court, will assure that the beaches will continue to protect upland areas from severe storm damage and will preserve the State's valuable fish nurseries, by one estimate the source of more than half the area's yellowtail flounder.

However, a number of thorny issues related to barrier islands and their development remain. Virtually every State with barrier islands has to wrestle with island-related issues, generally through its coastal zone management program. The problems include dealing with the potential catastrophe of a hurricane threat to a summer community, septic tank waste disposal, saltwater intrusion resulting from a drop in an island's water table, and the wisdom of dune stabilization in the face of continuous erosion.

Many State and Federal decisionmakers believe the greatest hope for protecting barrier islands and creating conditions in which people and the islands can live in harmony lies in strong State coastal management plans based on sound ecological principles. As the barrier islands continue to lure campers, residents, and visitors with all their modern impedimenta of hotels, marinas, condominiums, shopping malls, and roads, more and more State and local governments will be forced to take a hard look at barrier island development. In the end, if the problems are not answered at the human level, they will be answered by the natural forces surrounding the barrier beaches themselves. □

Storm-driven waves lash sea walk on Tybee Island, Ga. (above). Coastal residents on Casey Key, Fla., use old tires, rubble, wooden bulkheads and pilings in an attempt to stem erosion (below).

NOAA Profile

Arva Jackson's Message to NOAA

Don't Forget The People

By NORMA V. REYES

". . . what I'm looking for is the assurance that minorities and women are getting their fair share of the jobs and promotions."

"There is no such thing as reverse discrimination. You may be discriminated against because you're white, or because you're male. That's not reverse discrimination. That's straightforward discrimination! It applies just as much as if you're black and female."

Arva Marshall Jackson, NOAA's Director of the Office for Civil Rights, warms up to the subject of the Civil Rights Act of 1964. She feels a responsibility for her office to separate myth from fact. Because the Act covers everyone, including white males, she considers the concept of reverse discrimination to be a myth.

"When I look at the civil rights picture for NOAA, what I'm looking for is the assurance that minorities and women are getting their fair share of the jobs and promotions," she says. "And for me, the botton line is, what do our statistical profiles look like? That's the focus."

Arva Jackson knows there are many people in NOAA whose skills have not been tapped. She feels strongly that it is absolutely necessary for managers to recognize that the greatest resources available to them, no matter what the agency, are the people in it.

And people are very important to Jackson.

An alumna of the Wilmington, Delaware, segregated school system of the Forties, she delighted her parents when, at the age of six, she announced her plans to become a doctor. Their encouragement and support kept that goal alive through her years at Boston University, which she entered at 15.

The necessity of paying for some of her expenses during college caused her to take a job as a house assistant to the University's music teacher. Her main task was to cook all the meals. Since she didn't know how to cook, the practical teenager began the meals early enough to allow her time to redo the dish if it didn't turn out right the first time.

"I remember once I made a German chocolate cake four times before I got it to rise. I'd never used baking soda instead of baking powder. But when company came, I served it as though it had been the easiest thing I'd ever put together."

Cakes were not the only things that Jackson had to redo. She quickly found that her earlier schooling in Wilmington, where she had been valedictorian and had maintained the highest grade average in her high school class, had not prepared her adequately for college. It was a shock to her to realize that other students knew many things that she didn't. And so along with the regular assignments and texts, she found herself having to read basic books on the subjects she was studying.

Graduating at 19 with an A. B. in biology, but unable to get into medical school, she took a job with the State of Delaware. Living on the grounds, she worked at an institution for boys who had been abandoned or who had been declared by the courts to need supportive care.

The death of a young co-worker in a car accident made her realize that life could end at an early age. That realization led her to a major re-evaluation. She told her parents that she no longer wanted to be a doctor, although she still wanted to work with people.

She changed jobs to another state institution, a home for delinquent girls. There she understood for the first time that society treated girls differently than boys. The offenses that caused the girls to be committed to the home for delinquents were offenses that boys could commit without being institutionalized; pregnant girls were confined while the young fathers were not.

"No matter how terrible the home situation might be for some of the girls, many of them wanted to go home," she said. "I began to look differently at the kinds of situations we tend to brush over superficially as social ills, and to recognize that they are more complicated than they appear from the writings of sociologists.

"I lived with the girls day and night except for one week a month. Went to class often with them. We went out together. Movies. Roller skating."

These people were important to her, and she was important to them. Years later, when Arva Marshall had become Arva M. Jackson, her husband Wagner, then working for the Housing Authority and doing a house-to-house survey in Wilmington, came across a family with a child named Arva. He commented to the woman that the unusual name was also his wife's name, and the woman said, "Yes, I know. We named her after your wife."

In fact two of the young women named their girls after Arva Jackson. "At least I know that somewhere in this world I've made an impact," she laughed. Very seriously, she

added, "I learned that it's absolutely essential to understand people. You carry that impact with you."

So when the director of the state agency told her she'd make a great social worker, she applied to Howard University and received a $2,000 scholarship from the National Institute of Mental Health. "This was 1954 and I've never felt richer—before or since."

A week before graduating with a Master's in psychiatric social work, she was offered a job with a private non-profit agency, the Children's Bureau of Delaware, placing infants and young children in boarding care. Many of the children had been abandoned. In many cases the parents were no more than children themselves. In almost every case, she found the mother emotionally or economically incapable of assuming additional responsibility.

"Whenever it's possible, any kind of counseling given should be for the family." she said. Family counseling, whether together or separately, is important. "When you find a child with emotional needs who's in trouble, you almost invariably find parents who are in trouble, who need help as much as if not more than the child.

"I've often wondered whether or not most people who see themselves as capable and competent would be able to function as well, given the set of external circumstances that faced many of the people that I met during that experience.

"I have not sensed at NOAA—and perhaps there has not been an appropriate opportunity to do so—a real recognition of social circumstances, nor have I recognized any overwhelming sense of the need for the pulling together of people in order to make an effort go," she said. "In a scientific arena there is a tendency to be mission-oriented, and that's a perfectly acceptable way to function. But if you're mission-oriented and you forget that most missions are accomplished by people, then more often than not you don't get your mission accomplished."

Jackson doesn't consider herself an embodiment of civil rights. She firmly believes that equal employment opportunity and civil rights are management functions and that they will work only as well as management wishes. Her office has the responsibility to help management make them work, to help employees recognize what they can do to support programs that lead to management doing a better job.

Shortly after coming to NOAA in July 1978, she instituted a talent search, identifying the skills of current NOAA employees beyond what job descriptions ask. Now she travels to NOAA's field offices whenever possible, seeking answers to some questions and stimulating discussion about others. Are we sure the job requires the qualifications we list? If we end up with people of the same sex and race in a job over and over, can we be certain that we have identified the best recruits for that job? Do we keep going back to the same resources to recruit? Do we really believe that current recruitment sources are the only places that can produce qualified candidates? Is there something about NOAA that makes it difficult for women and minorities to rise?

"We make no judgments," she said about her office. "We intend to be, and in fact are, what I call truth-oriented. Know what is in fact the situation, what circumstances have led to their condition. Are these circumstances correctable? At what stage do we intercede? How do we insure that everyone under the Civil Rights Act of 1964 is covered?

"What we're looking at in NOAA is what has happened in the Washington metro area. How is it that we have a large minority and female population seemingly qualified for a variety of administrative and technical positions, and we don't find enough of these people in the upper levels of NOAA management?"

It raises questions. And the responsibility for the Office for Civil Rights, she feels is to ensure that this agency follows the intent of the legislation. "I do as much as I can to try not to short-change any area," she said.

She emphasizes that a similar approach applies at home. Her three children mean more to her than a clean house. "They won't be around much longer, but the dust will still be there."

"They're delightful children," she said with pride of Wagner, Jr., 18, an economics major at Harvard University, and Jeffre, 16, and Janine, 14, high school students.

When she married Wagner Jackson—now an official at the Department of Housing and Urban Development—and began her family, Jackson worked as a volunteer in her local community and found she was getting promoted more quickly than in her previous salaried jobs. She gained experience in program management that led to an offer to become director of Neighborhood Service Centers of the Greater Wilmington Development Council, Inc., a non-profit group. In 1969 she became Special Assistant for Human Affairs to the Governor of Delaware.

Her entry into the Federal Government came as Equal Employment Opportunity Manager at the Department of Health, Education and Welfare Regional Office in Philadelphia.

Jackson acknowledges that she has never felt terribly deprived—not when she had to work her way through college at the age of 15, nor when she had to study extra hard to make up for her high school's deficiencies. She has a good life, she says, and good relations with her husband and children.

But in her work she has met people whose circumstances deprived them of opportunities, and, she said, "there are lessons to be learned from that kind of experience—lessons that are applicable to what we have to do now to put together the kind of team effort that's required to make NOAA work for civil rights." □

1952 (top), with parents, Willie and Roy Marshall, at Boston University graduation. 1979 (below), with family, Janine, Jeffre and Wagner, Sr. (Junior is at Harvard.)

NOAA In The Chesapeake

By ROLAND D. PAINE

To be ignorant of the oyster was amusing, but to be unacquainted with the crab was pathetic.

Chesapeake, by James A. Michener

Chesapeake Bay is the largest estuary in the United States—193 miles long and 3 to 25 miles wide.

First explored and mapped by Capt. John Smith in 1607, its place in American history is reflected in the names of its major tributaries—the Susquehanna and the Rappahannock, the Potomac, Patuxent, and Patapsco, the Wicomico and the Nanticoke, the James, the York, and the Chester.

A British amphibious force sailed up Chesapeake Bay in 1814 and landed an army of Wellington's veterans who routed the American defenders of Washington, set fire to the Capitol and other public buildings, and sent the President and his family scurrying from the White House for safety. The same force later fled down the Bay, thoroughly trounced on both land and sea in a battle to which America owes its National Anthem; the composer, Francis Scott Key, was aboard one of the British ships in the Bay off Baltimore during the fight.

The shores of Chesapeake Bay vary from isolated marshes, whose silence is seldom broken but by the calls of Canada goose and heron, to the crowded cities of Baltimore near the northern tip and the Norfolk-Newport News-Hampton complex at the south. Baltimore is the sixth largest city in the United States, and in 1978 its port handled more than 4,000 ships hauling about 34 million tons of cargo—coal and grain exports, ore imports. The Virginia cities contain Naval and private shipyards that are among the Nation's largest, plus a vast array of commercial shipping facilities.

Chesapeake Bay supports a booming recreational boat industry—125,000 pleasure boats registered on the Bay from Maryland, countless more too small to be registered, and thousands more from Virginia.

The Bay's fecundity is almost unimaginable. Last year recreational fishing netted an estimated 50 million pounds of finfish, chiefly bluefish, spot, white perch, and striped bass (known to bay area residents as rockfish or stripers). Commercial fishing brought in much more—412 million pounds of menhaden (an industrial fish) were taken in 1978 from the Bay and its tributaries.

And shellfish. The blue crab is the staple of the area, and 35 million pounds of crabs worth $7 million were taken in 1976 by the watermen, as they are known locally. An additional 5 to 10 million pounds were caught by families on holiday.

That is a lot of crab—more than 125,000,000 crabs taken from the Bay in one year.

The most valuable catch, oysters, were hauled in to the tune of 20 million pounds worth about $19 million. A large fraction of this was brought in by a dwindling fleet of skipjacks, the last working sailboats in the United States.

Oysters, crabs, striped bass . . . The Bay is indeed productive; that it is also highly vulnerable is well known to the staff of the National Marine Fisheries Service laboratory in the charming little colonial village of Oxford, on Maryland's Eastern Shore (inhabitants of the long peninsula between the Bay and the Atlantic Ocean refer to it by its relationship to the Bay, not the Ocean). The laboratory built an international reputation through its work identifying diseases of marine animals, particularly a parasite called MSX (for Multinu-

Patchwork quilt is the Eastern Shore of Maryland, including the little town of Oxford on the Tred Avon River that empties into the Chesapeake. Facing page shows Tangier Island, tiny Virginia fishing community in the Bay.

Photo: Virginia State Travel Service

Photo: Maryland Department of Transportation

The Chesapeake Bay bridges just north of Annapolis that link the Eastern Shore with the mainland; freighters from all over the world pass under the bridge on the way north to Baltimore.

cleate Sphere X-unknown) that causes high mortality among Bay oysters and, later, an amoeba that kills blue crabs.

Threats come from human activities as well as natural causes. In December of last year NOAA Administrator Richard A. Frank protested to the U.S. Army's Chief of Engineers against the latter's recommendation that a permit be issued for construction of a marine terminal and oil refinery at Hampton Roads, Va., in a location that would pose a grave threat to the Bay's $87 million shellfish industry. Frank was joined in opposition by the Environmental Protection Agency and the Department of the Interior, the latter calling it "one of the worst locations in the United States" for a petroleum refinery.

In March, Administrator Frank renewed his opposition in a letter to Secretary of the Army Clifford Alexander, pointing out that the proposed refinery and marine terminal "would substantially increase the risk of oil spills in the sensitive lower Chesapeake Bay; that such spills could significantly threaten valuable resources in the lower Bay, including oysters, blue crabs, finfish, waterfowl, wetlands, and recreational areas; and that, on balance, Hampton Roads appears to be the worst of a number of alternative refinery sites on the East Coast evaluated by the Corps."

He cited data to show that the accident rate of large tankers of the size proposed for use at the terminal is more than nine times greater than the overall tanker accident rate for the Hampton Roads area, and that the current Hampton Roads accident rate for tankers is almost three times that of tankers of a similar size, worldwide.

Particularly vulnerable in the event of a spill would be the blue crab. Almost the entire population of Chesapeake Bay adult female blue crabs concentrates during the winter and spring on Thimble Shoals at the mouth of the Bay. They survive the winter by burrowing into the mud, and spawn in the area the following spring. A major oil spill in the area could seriously imperil the entire Bay population of crabs, the $39 million commercial crab industry, and the substantial recreational crab fishery.

A threat of that nature, which fortunately was dissipated without harm to the Bay, occurred in March when the Maria Costa, an Italian freighter laden with a highly toxic pesticide, anchored in the Atlantic off Cape Henry at the mouth of the Bay. The ship had sprung a leak, and ocean water that entered its cracked hull had combined with the pesticide to form a highly contaminated slurry, which, were it to escape into the ocean, would pose a grave problem. As many as 150 species of fish, some of great commercial and recreational importance, use the immediate area as a nursery.

Dr. Joel O'Connor of the MESA New York Bight Project flew to the scene along with NOAA fisheries experts and members of the

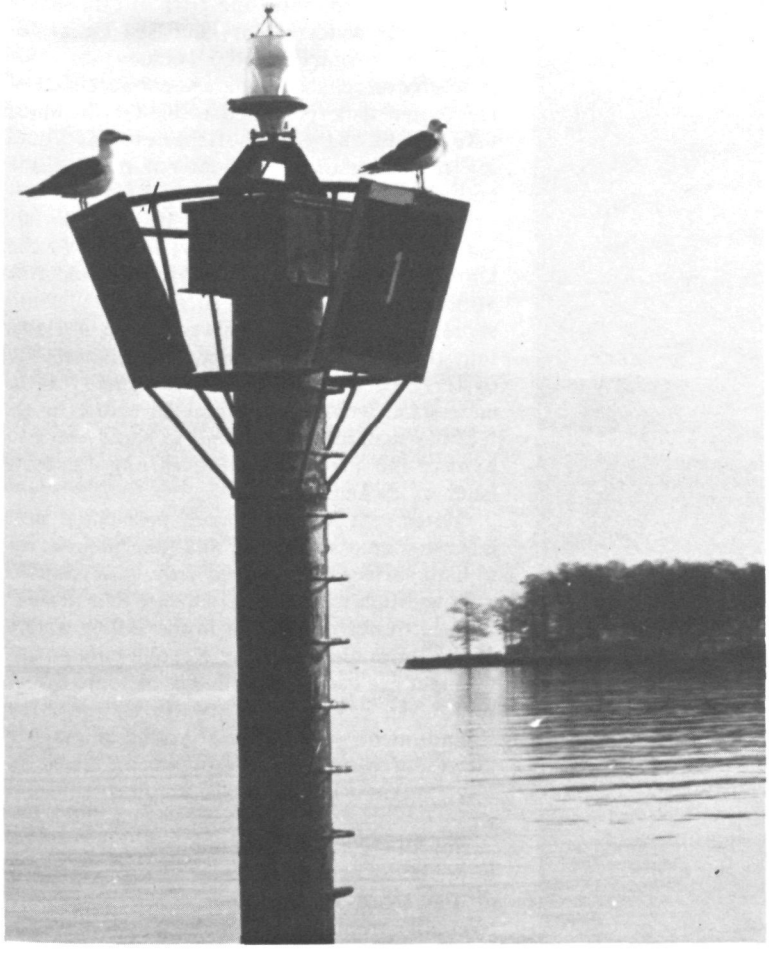


Photo: Maryland Department of Transportation

Photo: Virginia State Travel Service

From a small boat channel marker on an isolated backwater to the mammoth container ships in Baltimore harbor, everywhere are reminders of the Bay's nautical heritage. At left, a spinnaker run with Navy ship in the background in Norfolk harbor.

Hazardous Materials Response team (an outgrowth of NOAA's Spilled Oil Research teams), to give scientific support to the Regional Response Team, assess potential damage to the fisheries, and assist the Coast Guard's Marine Safety Officer in carrying out his duties.

Using a Navy helicopter and the University of Delaware research ship Cape Henlopen to measure surface and underwater currents and take water samples, the team determined that there was little if any leakage from the ship. Acting on a recommendation from the Regional Response Team, the Environmental Protection Agency issued an emergency dumping permit, the slurry was pumped from the ship into a barge, and the barge was towed far to sea where the slurry was dumped. This permitted the toxic materials to disperse rapidly and harmlessly.

As O'Connor pointed out, "The danger would come if it was dumped in the Bay's shallow water and allowed to settle to the bottom."

America's last fleet of working sailboats, the Skipjacks are still used during the bitter winter months for oyster dredging.

After several tries the Maria Costa was patched sufficiently well to proceed to a yard for permanent repair, and within a few weeks to set out again on her voyage.

Problems such as these are of primary concern to State authorities. During the past five years Maryland and Virginia have been developing coastal management programs, designed to provide for the wise use of coastal resources to ensure long term productivity of coastal areas. The Chesapeake Bay shoreline forms a major part of the coastal zone of both States, and the central thrust of both State programs is management of the Bay. NOAA's Office of Coastal Zone Management has provided funding support to the two States to assist them in devising their plans, and a bi-State Chesapeake Bay Legislative Advisory Commission has been formed to determine how management efforts of the two States can be made more compatible.

"The Maryland program is considerably advanced," said William Matuszeski, Director of the Coastal Zone Management Programs Office, "and in September of last year the State program was approved, and Maryland was awarded a grant of $1.4 million to administer it." Maryland had worked on its program for 4 years, with the help of $2.55 million in CZM funds during the period.

Matuszeski pointed out that Maryland's program is largely based on existing laws and authorities, while the projected Virginia program will require new legislation. The State failed to enact the new laws in the 1979 session, and will try again in 1980. Virginia had received $2,234,000 from CZM to assist in developing its program, but in the interim—until new authorities can be enacted—funding has had to be suspended.

Maryland's Department of Natural Resources has also received funds from the Coastal Energy Impact Program to study energy-related impacts in Baltimore Harbor, a petroleum storage project in St. Mary's County, and a liquefied natural gas facility in Calvert County.

State research as well as management activities on the Bay are also supported by NOAA through its National Sea Grant Program. A major part of the Maryland Sea Grant program is devoted to the Bay, whose ecosystem covers nearly 2,000 square miles in Maryland, and puts one-fifth of the State under tidal waters. Maryland Sea Grant focuses its research and advisory services primarily on rehabilitation and enhancement of the oyster fishery, which is by far the most valuable of the State's fisheries. Maryland regularly accounts for about one-third of the entire oyster output of the United States.

Dr. Stephen Sulkin, who specializes in larval development and ecology, is head of the University of Maryland's Horn Point Environmental Laboratories, located on the south shore of the Choptank River where it flows into the Bay. "Our projects relating to the oyster," he explained, "are designed first to understand what is happening in nature to affect the spat set, and second to study ways to bypass the critical period through use of hatchery technology."

Oyster spat are the young, post-larval animals that stop swimming and glue themselves to hard surfaces "set"—to grow into adults.

In addition to the MSX parasite that has decreased oyster production in the saltier waters of the lower Bay, and the Kepone contamination that has caused the closing of some oyster beds in Virginia waters, oyster "recruitment"—addition of young animals to the resource—has been dropping in the north Bay. Sulkin's laboratory is trying to find out why.

Not all the reasons, he believes, are related to predators or pollution. Dr. Victor Kennedy of the Horn Point faculty, working with biologists from Johns Hopkins University, located two creeks quite close together that appear to be very similar in such relevant characteristics as size, physical composition of the bottom, water quality, temperature, and salinity, yet one creek regularly has a good spat set, the other a poor spat set. Why? The scientists are now testing the idea that different current patterns in the water cause the difference.

Another Sea Grant project at the laboratory is looking into the relative efficiencies of various devices for collecting oyster spat off the bottom. Still others are concerned with studies of oyster growth rates and dietary requirements (it takes 4 years for the American oyster to reach marketable size in Chesapeake Bay).

In addition to the oyster, scientists at the laboratory are investigating aspects of the blue crab, which the Maryland Sea Grant proposal calls the State's "most unpredictable and second-most profitable commercially harvested species," and the deep-sea red crab, a relatively new commercial fishery in the Atlantic Ocean.

The blue crab studies are designed to find out more about the true source of recruitment of young, and what causes the large fluctuations in population. "We now think that the critical stage is the larvae" Sulkin explained. "The general assumption has been that the larvae come from Chesapeake Bay. But there is an alternative—maybe there is considerable recruitment from offshore. If so, maybe fluctuations in this source at least partly explain fluctuations in the Bay supply."

Scientists from the University of Delaware

Sea Grant Program and the Virginia Sea Grant Program at Old Dominion University are working with the Maryland group on this problem.

To assist future management of the Chesapeake Bay ecosystem, Maryland Sea Grant also carries out research designed to find "resource indicators" that can warn of deteriorating environmental health or increasing pollution. One such project examines inaccuracies in current coliform tests used for public health safety. Another area of research designed to contribute to better management is working toward a more detailed understanding of the various pollutants that enter the Bay from agricultural, domestic, and industrial sources.

The Virginia Sea Grant Program is based in the Virginia Institute of Marine Science (VIMS), with an advisory service program maintained at Virginia Polytechnic Institute at Blacksburg. VIMS has had a decade of Sea Grant support, and carries out research both from its main campus on the York River and a branch site at Wachapreague on the Eastern Shore. Mollusc fisheries and aquaculture, crab fishery technology, and fish breeding have been important research subjects for VIMS Sea Grant. Among the accomplishments of this work that are important to the Bay have been:

- Year-round conditioning and spawning of oysters, leading to the availability of a constant supply of larvae and spat for commercial hatchery applications and for laboratory research;
- Development of MSX-resistant oyster brood stock, and improvement in the hereditary marketable attributes of these oysters;
- Development of a new system to set and hold oyster spat to reduce the cost of hatchery-reared seed to a level where it can compete favorably with wild spat (oyster spat transplanted to other growing areas are called oyster seed).

The VIMS Sea Grant Program has also established the National Aquaculture Information Service, a component of NOAA's OASIS system, and published a thesaurus of terms related to aquaculture for use by industrial, educational, and research-oriented users.

For many years the National Marine Fisheries Service Laboratory at Oxford, Maryland, has carried on research that complements the work of university and State scientists interested in the Bay. "One cause of the laboratory's thrust—animal disease research—was a crisis," said acting laboratory director Dr. Robert Murchelano, "and we have responded to many others since then. The first was the catastrophic mortalities of oysters in the Bay, from which the resource has never fully recovered."

The Oxford laboratory, along with others, immediately set to work to find out the cause, and eventually scientists discovered and identified as the culprit the organism they call MSX.

The Oxford laboratory, now part of the Northeast Fisheries Center, began by working on oysters and then other molluscs such as clams and mussels, until in the late 1960's another crisis involved them with another class of animals, the crustaceans. This crisis concerned blue crabs.

Crabber pulling in a crab pot.

"Soft shell crabs are more valuable than hard shells," Murchelano explained, "and so the watermen who catch crabs about ready to shed their shells put them into 'shedding tanks'. Once the crab sheds, it is removed before the new shell hardens, and marketed."

Heavy mortalities of crabs in shedding tanks caused the laboratory to devote much attention to the problem, and the biologists discovered the cause to be an amoeba. The disease was called "gray crab disease", because the crab's abdomen turned from its normal healthy creamy white to gray. Unlike the MSX problem with oysters, this disease cannot spread easily because diseased crabs are simply removed from the tanks and destroyed.

The laboratory houses the National Registry of Marine Pathology, and is in the process of developing an international network of such registries. It is an internationally recognized diagnostic center for health in marine fish and shellfish, and many scientists, both U.S. and foreign, go there for training.

"We receive animals from foreign and State governments and from industry, who want to be sure that they are not diseased," Murchelano said. "Maine, for example, has very rigid shellfish health standards—it wants to be sure that no diseased animals are brought into the State. The only agency presently giving this certification is this laboratory."

On a day in early April, a visitor to the laboratory saw abalone from Alaska and hard clams from Massachusetts, sent by firms that wanted to introduce them to waters of other States and needed certification that they were healthy.

The laboratory is participating in the National Ocean Survey's Ocean Dumping Research Program, examining euphausiids—a shrimp-like animal—in the vicinity of Deep Water Dumpsite 106, an industrial waste dumpsite. The laboratory is trying to find out the consequences, if any, of the dumping on these animals, which were chosen because they are important in the food chain and are abundant at Deep Water Dumpsite 106.

"This research is also part of the overall Northeast Fisheries Center Ocean Pulse program, which is trying to find animals that can serve as sentinels of environmental change," Murchelano said.

NMFS recently established an Office of Habitat Protection to work with other elements of NOAA toward habitat protection measures in Federal water project permit and license programs. Staff members work on habitat protection programs for the waters and wetlands of Chesapeake Bay out of the Oxford laboratory. They review and comment on proposed developments that may affect the marine aquatic environment.

The Fishery Market News program which provides current fisheries information to fishermen, processors, wholesalers, retailers, Government agencies, and others, has Market News reporters stationed in Baltimore, Maryland, and Hampton, Virginia, to report on prices and other items of interest from the Bay area.

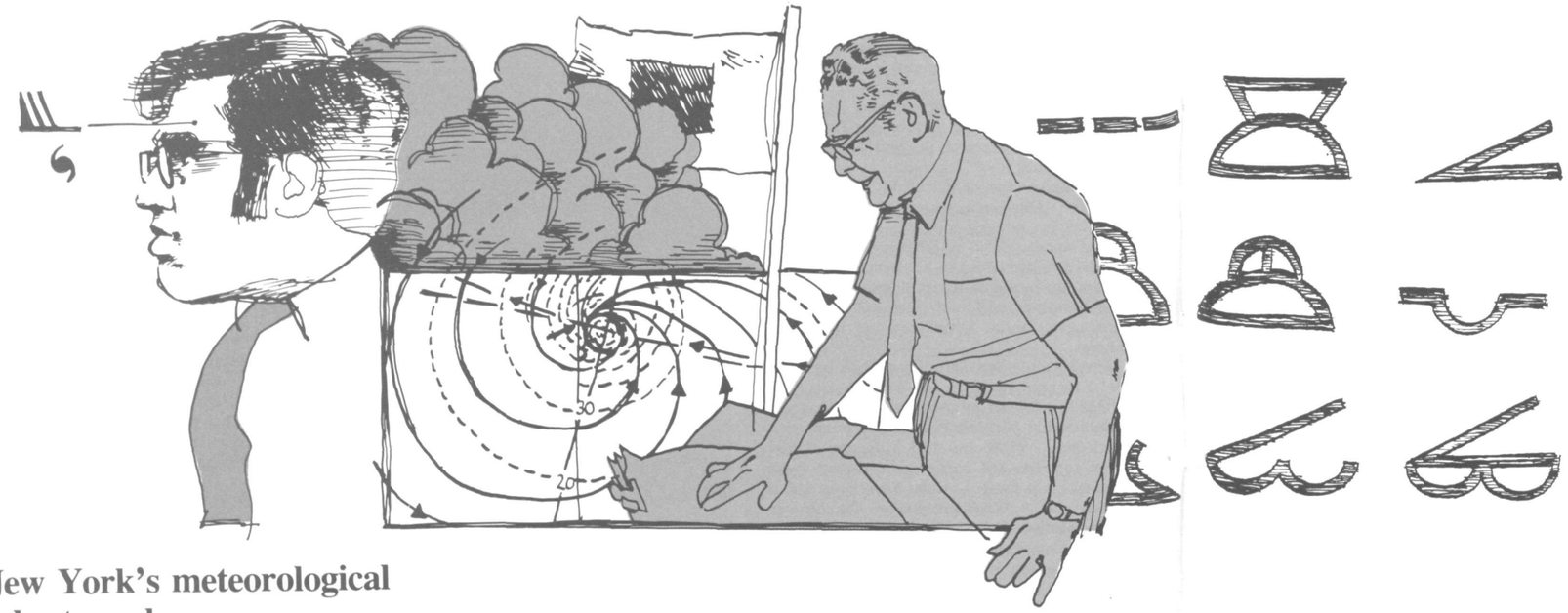
NMFS also maintains a grant-in-aid program that assists State resource agencies through funding for fishery research and development projects. At present, $494,000 has been made available for finfish and shellfish research, including work on marine disease organisms, oyster habitat rehabilitation, marketing, statistics, and technical assistance. An additional $192,000 has helped Maryland undertake an inventory of anadromous fish spawning and nursery habitat in the upper Bay, and helps Virginia carry out a study of river herring and shad in the lower Bay.

Other NOAA components also work on many tasks relating to the Bay.

NOAA's billionth nautical chart, published as part of the Bicentennial observance, was a chart of the Chesapeake Bay harbor of Annapolis, capital of Maryland and home of the U.S. Naval Academy.

In addition to studies of deep water dumpsites, the NOS Ocean Dumping Program funds physical oceanography and physiological studies of the effects of disposal of dredge materials from Elizabeth River and lower Chesapeake Bay dredge locations upon the local plants and animals at the dumpsite. The Environmental Data and Information Service national data repository for oceanographic and atmospheric data includes that for Chesapeake Bay, and EDIS has contracted with VIMS to produce an Environmental Data Index for the Bay. The National Weather Service marine weather program includes services from Washington, Baltimore, and Norfolk that contribute to the safety of life and property of the many marine users in the Bay.

Dr. Ferris Webster, NOAA Assistant Administrator for Research and Development, summed it all up in a recent statement to a United States Senate Governmental Affairs subcommittee'; "NOAA has a major commitment to the preservation of this great estuary and its living resources." □



New York's meteorological volunteers have

Weather In Their Blood

By CHARLES G. THOMAS

Harvey Thurm, a 31-year old meteorological intern at the Weather Service Forecast Office in New York City, specialized in NOAA Weather Radio. He spent many hours each week writing and broadcasting the program that went out on KWO-35, New York's VHF-FM continuous weather broadcast station. Like the professional he is, he remained on duty at the Rockefeller Plaza Office for a 48-hour marathon stint in August of 1976 when Hurricane Belle roared up the Atlantic coast. He was given a NOAA Public Service Award for this effort.

A dedicated employee . . .

But there's something else you should know about Harvey Thurm. For three years—while he was broadcasting on NOAA Weather Radio, while he was putting in hour after hour at the New York WSO—Harvey Thurm didn't get a penny in wages! As a matter of fact, he wasn't even a Government employee. He had a regular job with a New York premium finance company.

Harvey Thurm was one of the first to serve in a volunteer program at the New York office which provides a corps of unpaid workers to augment the station's regular staff.

"During these belt-tightening times of employment ceilings and staffing cutbacks, our office has had a rather welcome invasion of unpaid help," according to Harold M. Gibson, Meteorologist in Charge of the station.

Harvey Thurm led this friendly invasion about four years ago.

Since then, the number of volunteers has fluctuated. A high was reached in 1977 when there were eight unpaid workers coming on a regular basis. Today there are four.

"Most of our volunteers," says MIC Gibson, "are trying to learn and develop the skills required of a good forecaster. Typically, they aid the duty forecaster in the dissemination of weather information, they handle NOAA Weather Radio duties, they answer the telephone—they fill in anywhere help is needed. During storms their help is particularly valuable.

"Joe Cioffi, Chris Barbarantz, Steve McIntyre, and Bob Higgins, all unpaid volunteers, combined to put in nearly 100 hours of work from February 5 through February 7 during the great Northeast snowstorm of 1978."

Why did Harvey Thurm leave his job for two days to help with Hurricane Belle? Why did Steve McIntyre, who goes to college and works for an insurance company, make time to come in during the worst winter storm in years? And Abe Zwecher, 67 years old and retired after almost 45 years of Government service . . . why does he work at the forecast office five days a week, five hours a day?

"I was working at the finance company, nine to five, every weekday," says Thurm. "But I've been what they call a 'weather nut' all my life, I love anything to do with the subject. I earned a college degree in meteorology, but when I got out of school there just weren't any openings in the field. A guy's got to eat, so I took the best job I could find, but I still had this thing for weather, So one day I went to Mr. Gibson and volunteered my time. Mr. Gibson was willing to try me out, and I started my National Weather Service career the next day.

"I'd get off work from my regular job at 5 p.m. and go right over to the Weather Service where I'd stay on until around ten in the evening. I followed this routine three days a week—more if there was a severe weather situation and my help was needed. These were long hours—up at 5:30 in the morning for my regular job and then working on though the evening at my Weather Service job—but it was a labor of love. I enjoyed the time I spent in meteorology. It was actually a way of relaxing after 'a hard day at the office.' "

Like Thurm, all of those involved in the volunteer program at the new York Forecast Office have an abiding interest in weather and Weather Service activities, but it would be impossible to characterize a "typical" volunteer.

Many are students with an academic major in meteorology. Most of them are aware that the experience they are gaining can't hurt if they apply for full-time employment with the National Weather Service.

"One of the big advantages of the volunteer program," Gibson says, "is that the prospective employer and employee get a good look at one another before either is committed. The volunteer has the opportunity to see what the job is really like before entering the field, and it is obviously an advantage to the National Weather Service to see capabilities of potential employees before taking them on permanently. Several former volunteers are now members of the official staff at the forecast office, including Thurm, Ralph Izzo, a two-year volunteer, and Joseph Cioffi, a volunteer for two and a half years, has just accepted an appointment with the Weather Service at Ft. Totten, N.Y.

But there are notable exceptions to the young college students who seem to dominate the volunteer program.

Jonathan Smith, a high school student, was the second volunteer. He was at the New York office for one school semester, working four days a week under a cooperative training program with the New York City public school system. Since Smith's tour in 1975, three other high school students have worked as volunteers under this program.

And then—perhaps the most un-typical of all—there's Abe Zwecher.

Zwecher, who retired about two years ago, was a forecaster and a radar specialist at the New York WSFO for a number of years. Before then his career stretched back to river flood forecasting in Hartford, Conn., during the floods of 1938 and the snows of 1947. But now, after 45 years of weather and a well-earned retirement, Zwecher is back in harness.

"Abe loves what he does. He's addicted to it," Gibson, says. "When he retired about a year and a half ago, we thought we'd lost all of his valued experience in meteorology for good. It was a real break getting him back, even if it isn't full-time. He's become sort of a symbol of the whole volunteer program.

"Abe's a perfectionist. He keeps the NOAA Weather Radio in perfect running condition, making sure all of the observations are put on the air on time. He's responsible for making the special weather map for the Associated Press wire service. He does the daily WNYC National Public Radio weather broadcast for us. In addition to his own work, Abe's always ready to offer help and constructive criticism to the novices. When a person with all of those years of experience behind him speaks, the younger crowd would do well to listen. I have, and I've benefited greatly."

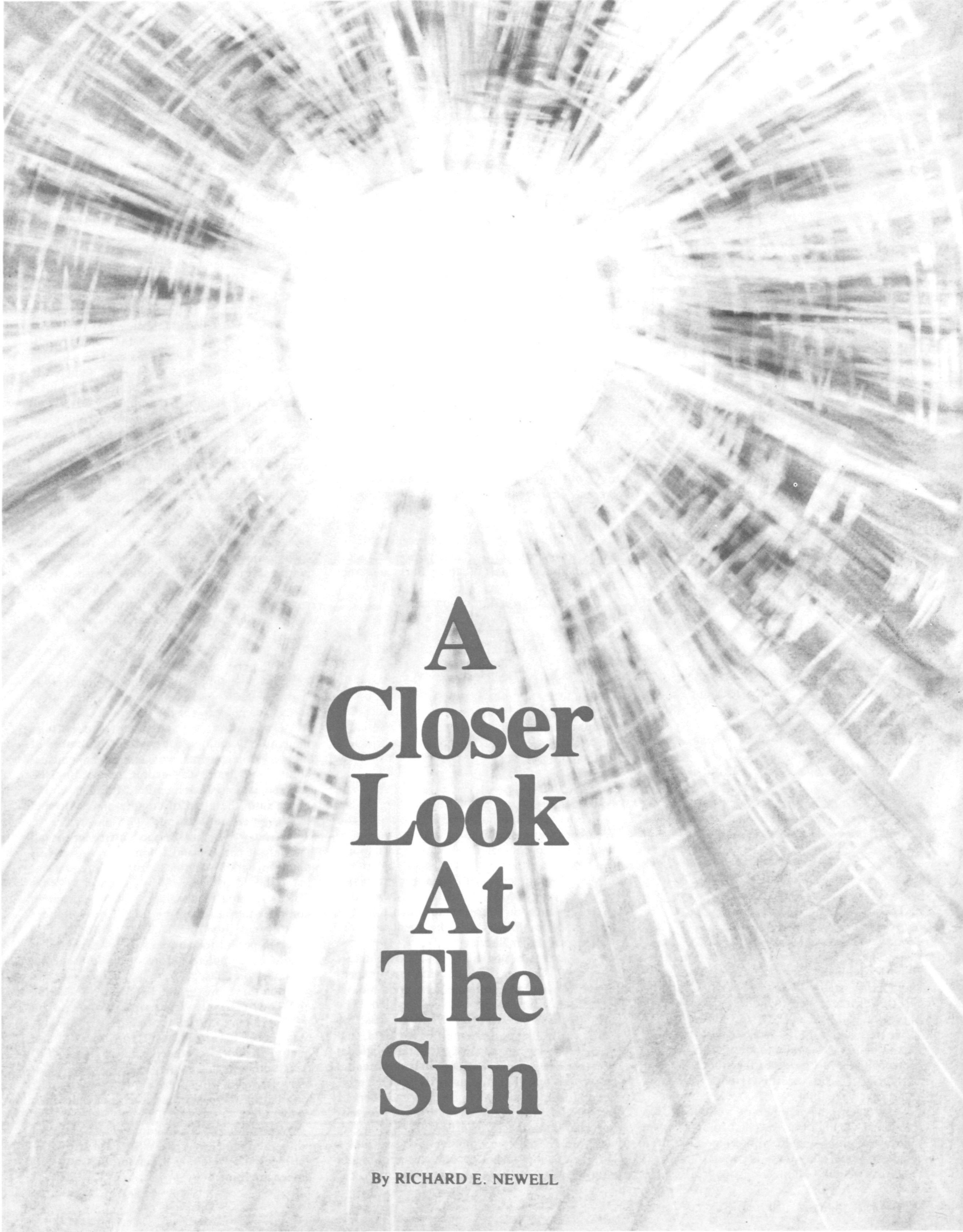
Today, the supply of potential volunteers is so large that Gibson has become quite selective in his choices for the program.

"I now limit my volunteers to college meteorology majors, a very limited number of high school students who exhibit an unusual ability and desire to become meteorologists, and special cases such as Pat McEntee who is going into the field of commercial radio and television weathercasting," Gibson says.

"A busy Weather Service office needs all the help it can get and I don't see why a volunteer program wouldn't work in any station, but I should offer a word of caution to other offices. If you're developing such a program don't let the tail wag the dog. One volunteer on duty at any one time is enough. The break-in period for an inexperienced volunteer should be complete before bringing a second volunteer on board.

"But these are bright people we're taking on. The relatively short time we spend on training them in office procedures is a remarkably good investment for the amount and quality of work we receive in exchange. Offices will find that if they take on one volunteer, the word will spread rapidly. It won't be long before there will be more applicants than can be used.

"We still worry about employment ceilings, but here at the New York WSFO at least we're getting some welcome relief through our volunteer program. □



A Closer Look At The Sun

By RICHARD E. NEWELL

At the NOAA/Air Force space weather center in Boulder, Colo., a forecaster works at a small light-table, tracing features of the Sun's magnetic fields from a photograph taken just an hour earlier. Forecasters have come to depend on these unusual weather maps for a clear view of the day's solar activity.

Regions of "stormy" sunspot activity have been observed in detail ever since the telescope was invented more than 350 years ago. Sources of violent and sporadic solar flares, they have been mapped for many years. Less attention has been given to the areas of "fair" solar weather in between—the vast areas of weak magnetic fields that tie into the active regions to form a unified coherent system.

Ten years ago, Patrick S. McIntosh prepared the first rendition of a solar weather map that included the fair weather component with new clarity. Today, he and the other forecasters of the Space Environment Services Center in Boulder, Colo., conduct the world's only weather mapping effort in support of daily predictions, as a part of their effort to issue timely and effective forecasts of the Sun's influence on our lives.

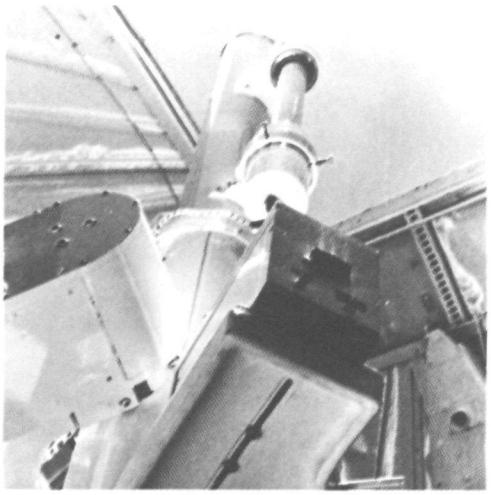
To the solar disturbance forecaster responsible for issuing the day's forecasts and alerts, the maps are a useful tool—another handle on what's happening on the Sun. Some solar scientists are even confident that the maps will have value for research as well as prediction.

Each day's map is derived from a full-disk photograph taken at a certain wavelength of light, the red (alpha) line of the hydrogen spectrum—the best view available of sunspots, flares, and their interconnecting magnetic features. The Sun has been photographed for more than 70 years through small telescopes equipped with "H-alpha" filters, which only transmit the hydrogen-alpha line. These photos are the primary means of monitoring solar flares and related activities.

H-alpha telescopes are used at most of the solar observatories around the world and are an essential part of the global Air Force-NOAA Sun-monitoring network. Recently, they have been joined by computerized telescopes which collect a variety of observations in terms of numbers stored on magnetic tapes. However different their makeup and origin, the maps and tapes have a common purpose: to observe and study the Sun in a systematic way.

The solar weather map emphasizes the capacity of the human mind to deal with subtle relationships between features that we can't yet put numbers to. The story of the maps deals with a discovery that, like many other important discoveries, came about as the result of going over old territory with a fresh eye. It is also intriguing because it parallels the story of traditional weather maps in many ways.

Solar maps originated in Europe, just as atmospheric weather maps did. Both stormy and quiet components of solar weather have appeared for decades on maps prepared in France and Germany, but these versions are incomplete. Then in 1955, a half-century after George Ellery Hale used his new spectroheliosscope to discover that sunspots were the seats of intense magnetic fields, a magnetograph was developed for mapping these fields



The best available view of sunspots, flares, and their interconnecting magnetic features is provided by the "H-alpha" telescope, which is equipped with a filter that transmits only the light in the alpha line of the Sun's hydrogen spectrum.

over the entire solar surface. This device, invented by Horace Babcock of the Mt. Wilson Observatory in California, showed that there were extensive, but weak, magnetic fields far removed from sunspots, prompting intense study of the relationships between solar magnetic fields and related solar-terrestrial disturbances.

The new maps devised by McIntosh reveal a startlingly crisp view of the magnetic patterns and link them into giant systems not clearly seen with even the modern magnetographs. The patterns of magnetic sign and intensity recorded by these devices are indistinct, as if out of focus. Nevertheless, these records are essential for many studies of solar activity and are not replaced, but complemented, by the new maps of the Sun's magnetic fields.

McIntosh began to explore the Sun as a "backyard" astronomer during his teenage years. He became fascinated with sunspots, observing a sense of order and regularity in their distribution and fine structure. He later studied astronomy at Harvard College and worked as an assistant at the Sacramento Peak solar observatory in New Mexico. He learned that the sunspot structure was produced by magnetic fields and surmised that it would be useful to be able to infer magnetic field information from the wealth of detail visible in sunspots photographs.

When, years later, he succeeded in inferring the Sun's magnetic field patterns, it was not from sunspots alone. The view of the Sun available through an H-alpha filter revealed even more fine structure, including patterns resembling iron filings scattered about a magnet.

Babcock's magnetograph had already shown that the positions of magnetic polarity reversal on magnetograms corresponded closely with the long, dark, gaseous H-alpha filaments so familiar to solar observers. This meant that the filament fragments tended to outline the large-scale magnetic fields.

McIntosh discovered that he could link these fragments together to form a continuous magnetic pattern by carefully tracing the interconnecting avenues of fine fibrils, which he called "filament channels." The resulting lines, running continuously along filaments and filament channels, are magnetic "neutral lines," where the polarities of the large-scale magnetic fields change sign. He used the generalized features of the Mt. Wilson magnetograms to verify the neutral line patterns and the polarities of the adjacent magnetic regions.

The new maps are much like those of the Scandinavian weather pioneers of some 50 years ago—hand drawn, with patterns carefully analyzed to fit the data and reflect day-to-day continuity. One of their greatest advantages is the ease and economy with which they can be produced. This helps forecasters to meet the need for regular and timely predictions of solar disturbances.

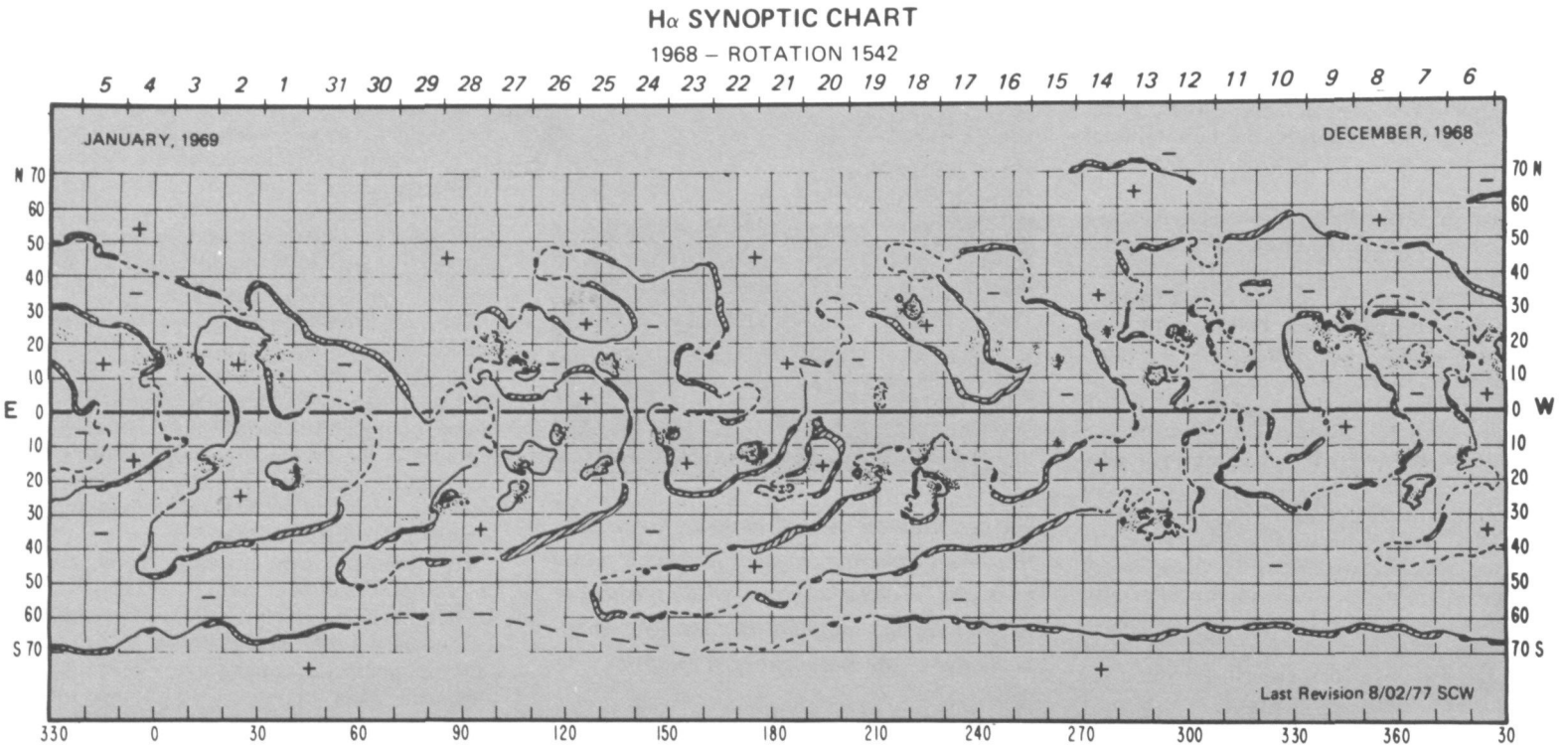
To McIntosh's eye, his early maps showed that complexes of solar activity tend to form at the neutral lines, implying that observing and understanding the evolution of neutral line patterns would be important to solar activity forecasting. But the maps held promise for research in other directions, too.

"It was due to the vision of researcher Ed Roelof that progress with the maps went forward at the pace that it did," explained McIntosh. Dr. Edmund C. Roelof was in the audience at a scientific meeting in 1970 when McIntosh presented his first H-alpha map. "He immediately recognized its value to his solar research," said McIntosh, "and encouraged me to start a series of maps and to refine them to show even more detail. He really pushed me on it. If it weren't for his moral support and, through him, the financial support of the Air Force's Geophysics Research Laboratory, I wouldn't have been able to undertake the mapping project that followed."

With a staff of cartographers, and on time borrowed from other assignments with the permission of his supervisors, McIntosh proceeded to map the face of the Sun for a complete solar sunspot cycle—10 years of solar activity. This would give researchers like himself and Roelof the solid data base needed to examine important problems of solar-terrestrial physics: did the interplanetary magnetic sectors imbedded in the outflowing solar wind particles have their source among the giant patterns of neutral lines; why do these large-scale magnetic patterns move, merge, divide, and expand as they do; and how do these movements relate to the large-scale solar circulation, to sunspot and flare activity, and to the global magnetic polarity reversal that occurs about two years after the peak of each solar cycle?

Each atlas chart displays the entire solar globe much as a flat wall chart of the world. But since the magnetic features of the rotating globe are viewed over a period of 27 days, the horizontal axis of the chart is labeled in terms of time as well as longitude.

The H-alpha atlas for Solar Cycle 20 (1964-1974) makes a large body of this information available to researchers for the first time. The project involved much more time and energy than McIntosh expected, averaging more than 120 working hours for each of the



One of 130 "weather maps" of the Sun appearing in a solar atlas prepared by NOAA's Space Environment Services Center. Each chart is based on a sequence of daily photos taken through a solar telescope over a period slightly longer than one 27-day solar rotation. Undulating lines represent magnetic "neutral lines", separating areas of positive and negative magnetic polarity. They are associated with bands of cool, dark gas (filaments) shown in hash-marked sections. Adjoining segments are mapped from finer-scale details. Sunspots are also shown.

130 solar charts; and a tight budget produced some hardships along the way. But the final product is more comprehensive than originally planned. Since all the important aspects of each day's magnetic activity could not be included on the charts, he provided copious notes, describing the features and possible interrelationships that might be of value to investigators.

Thus far, the maps and the charts have been available on a limited basis, and mostly in preliminary form. Perhaps for this reason, the reaction of researchers and forecasters has been mixed. Both groups have found them to be a convenient way to see how solar features are organized and how the magnetic patterns evolve from day to day. But some users find that what they can do with a sequence of patterns is limited. They want objective measurements that they can plug into equations or plot on graphs.

McIntosh agrees that the maps are still in a primitive state of development and are just beginning to have an influence on solar activity forecasts, and he feels that putting numbers to the maps should be a primary goal. Meanwhile, he has already used the maps to prepare a nonnumerical circulation study, and also sees other ways that the patterns can be used effectively. The real proof of the value of the solar maps and the atlas, he says, will have to await the research findings that he anticipates will come from it.

H-alpha patterns reveal the basic features of the Sun's magnetic systems to skilled solar analysts as readily as the cloud patterns of Earth reveal the gross features of weather systems to satellite meteorologists. These features, as depicted on the weather maps of Sun and Earth, have some interesting, if superficial, similarities. There are huge, shifting regions of contrasting makeup (air masses versus "unipolar magnetic regions") separated by distinct boundaries (weather fronts versus neutral lines). Centers of activity (storm centers versus "active regions") spring up from place to place along the boundaries and persist, at varying levels of intensity, for long periods of time. Vigorous surges of energy (thunderstorms versus solar flares) periodically break out within these centers.

The most stable of the active solar features are "coronal holes," parts of magnetic regions where the field lines open up to space. Their steady, high-speed particle streams are the source of about 90 percent of the solar wind. Together with the sudden, violent solar flares, they are major sources of the magnetized, electrically charged particles that sweep through space to produce geomagnetic storms and other terrestrial disturbances.

Forecasters use H-alpha maps to tie the solar features into a coherent system. Although the forecasting problem is complicated by the fact that any given point on the rotating Sun is visible to us for barely two weeks at a time, the persistence of coronal holes and flare-prone active regions from one rotation to the next makes the problem manageable. The maps, by presenting the clearest view so far available of the big picture of solar activity, could be of central importance in advancing forecasts of the large-scale solar circulation along the path already taken by atmospheric weather forecasts.

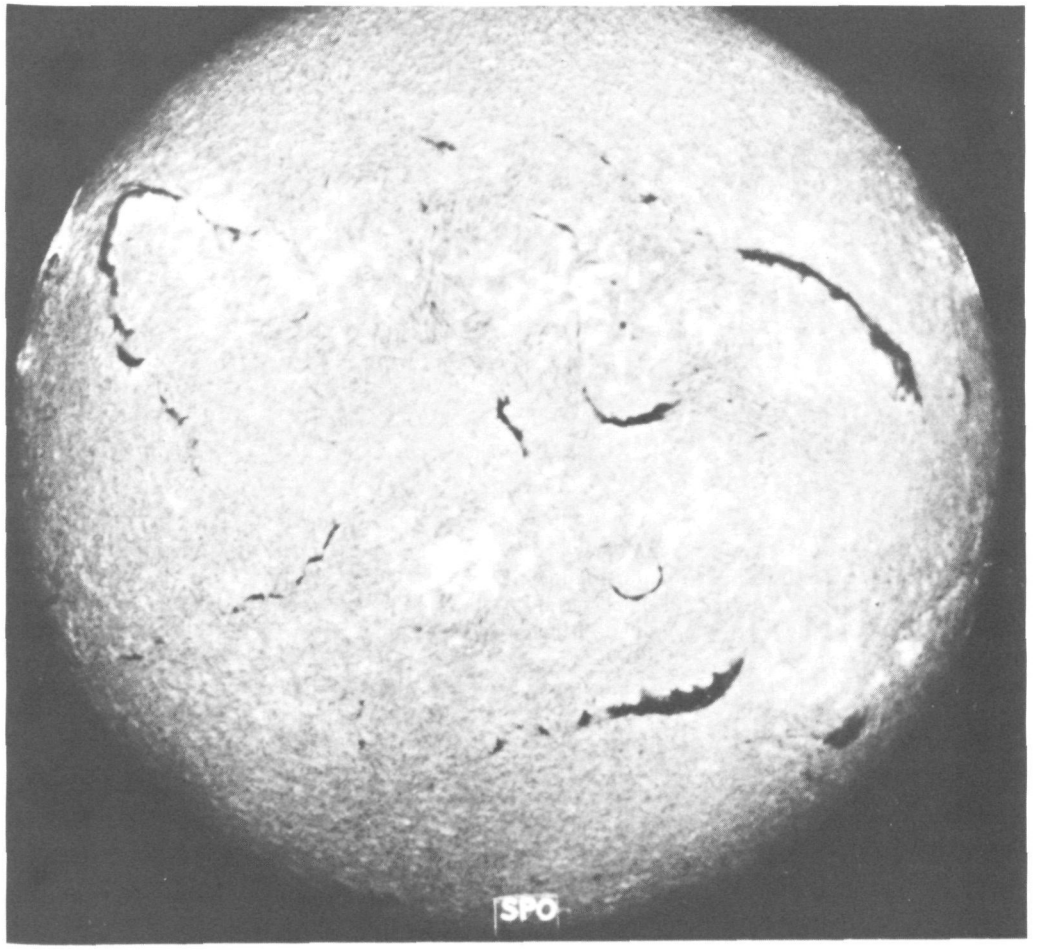
Forecasts of large-scale atmospheric weather patterns are now largely automated, and this is the goal for solar forecasts too. In each case, the same basic procedures are involved—global observations and advanced computers are used by researchers to develop global circulation models, to which the latest observations are applied to obtain computerized forecasts of the circulation patterns.

Even now, the charts of the completed H-alpha atlas for Solar Cycle 20 are being digitized so researchers can analyze the patterns with computers. McIntosh suspects that the evolution of these patterns reflects the large-scale flow of solar gases. "This digital data," he says, "may be the basis for the first concerted study of the global dynamics of solar activity. The goal would be to develop the first numerical model of the Sun's global circulation, and then relate the model to the physics of forming and dissolving sunspots and the associated violent eruptions."

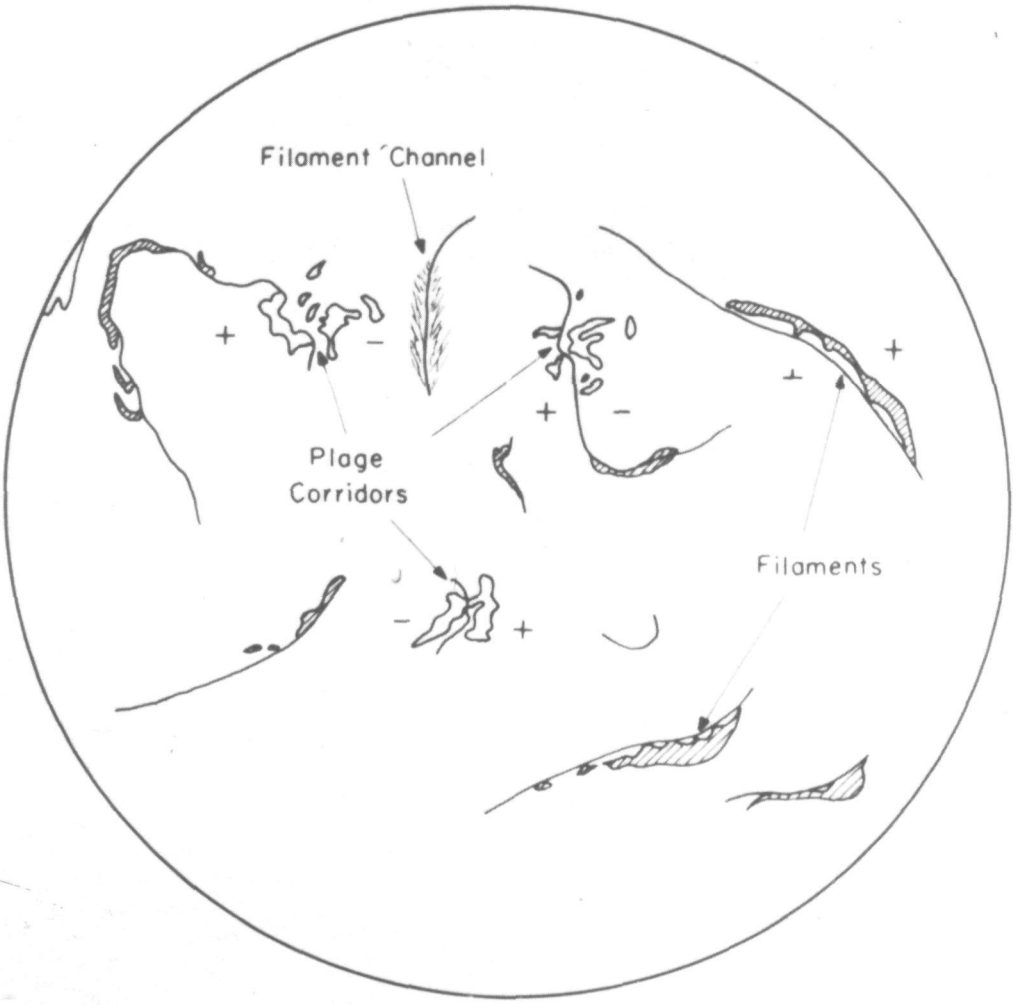
McIntosh's recently prepared model, based only on the H-alpha maps, deals specifically with the origin and evolution of coronal holes. He discovered that they originate within especially large unipolar magnetic regions centered near the solar equator, forming just before the equatorial region merges with a low-latitude extension of a polar region having the same magnetic polarity.

The systematic nature of these merging events and the long lifetimes of all these features gives McIntosh hope that coronal holes eventually can be forecast up to a year or two in advance, with a timing error of no more than a week. This would allow forecasts of the same general range and accuracy to be made of the associated magnetic storms here on Earth, with each coronal hole giving rise to a series of recurring storms—a storm for each monthly sweep of the rotating "solar sprinkler."

The solar maps, like the first Earth weather



This Sun view, as seen in "hydrogen-alpha" band of visible spectrum, is basis for map below. Such maps are used by NOAA forecasters to help predict solar and geomagnetic activity. Mappers identify magnetic "neutral lines" that separate regions of positive and negative polarity. They may affect Earth's magnetic field and its weather.



maps, may be the key to understanding many fundamental physical processes. What they can tell us about magnetic regions and coronal holes may help us to explain the magnetic structure of the solar wind, giving us a more complete understanding of the linkup between Sun and Earth that powers our magnetic storms. Recent findings by prominent scientists suggest that this same magnetic Sun-Earth link may also produce far-reaching changes in our weather and climate. This presents the fascinating possibility of forecasting our weather on Earth with the help of solar weather maps.

While other scientists seek to explain the most recent correlations between atmospheric and solar phenomena by studying thunderstorm electrification of high-altitude electron showers, McIntosh looks to his maps. One of their uses will be to establish the relationship between large-scale solar magnetic features and the magnetic structure of the solar wind. "There are still more than 55 years of unexplored solar history locked in the H-alpha archives," he says, "—the equivalent of about five solar cycles. When the time comes for that backlog of photographs to be mapped and studied, we will have a better chance to see just how far-reaching the Sun's magnetic effect on the Earth really is."

H-alpha maps eventually may be used in ways that McIntosh never envisioned 10 years ago. In fact, they have already been used in ways that might have seemed fanciful then. Aside from their direct contributions to solar research and forecasting, they have been used in space by Skylab astronauts to provide guidelines for targeting their instruments on solar features of interest to earthbound investigators. And earlier this year, forecaster Joseph Sutorik used H-alpha charts to make a 1-month prediction, for the news media, of the appearance of the corona that would be seen by total-solar-eclipse watchers in the northwestern United States and central Canada in late February.

To make his forecast, Sutorik studied 27-day charts going back for four solar rotations. "These charts show the past evolution of the Sun's large-scale magnetic structure for about as many rotations as you'd wish to see," he says. "It's the only way we have to make a forecast of this type."

The decision to take a closer look at the Sun by scrutinizing the details of daily H-alpha photographs collected for the past 70 years is helping to bring the big picture of solar processes and interactions into clearer focus. "This is an area of solar physics that was being sorely neglected," says McIntosh. The efforts that he and his supporters have put forth to remedy this neglect have opened up exciting possibilities for a fuller understanding of the Sun and the Earth. □

Special service, SOSU style

Fishermen's Friends In The Weather Service

Fishermen along the Pacific Coast have traditionally made their best catches of albacore tuna in the warmer waters offshore. Some speculate that other fish, such as salmon, may also prefer water of a particular temperature. The National Weather Service is helping them find those waters.

Locating areas of particular sea-surface temperatures is one of the varied tasks of the Seattle Ocean Services Unit (SOSU), which was created in 1976 at the National Weather Service Forecast Office to improve weather and oceanic services to Northeast Pacific mariners. SOSU also distributes sea ice information to local commercial shippers (many of the supplies bound for Northern Alaskan ports depart from the Puget Sound region, and safe, economical delivery is dependent on ice conditions en route), and produces daily experimental bar forecasts for the entrances to Grays Harbor and Willapa Bay on the Washington Coast, During the last several in-port seasons, the unit also has offered an eighteen-hour course on marine meteorology in the northeastern Pacific to NOAA ship personnel, and a shorter version to scientists of the U.S. Geological Survey at Menlo Park, California. Should there be an oil spill in the waters of Washington State or off its coast, SOSU would work with the modelers of the Pacific Marine Environmental Laboratories to forecast the path of the oil.

Of most use to northwest fishermen, however, has been the Thermal Boundary Analysis Program.

During this spring and summer of 1976 meterologist Bob Anderson made two trips to the Washington coast to meet with marine advisory agents and several fishermen. "The meetings were intended to discuss marine weather services," he said, "but everyone expressed a great deal of interest in information on sea surface temperatures. They particularly wanted to know about thermal boundaries, where there is a marked, well defined difference between cold and warm water. So during the 1976 fishing season we tried to obtain charts showing that data."

Such charts are produced by the National Environmental Satellite Service (NESS) in Redwood City, California. During that season, very little temperature structure was shown off the coast of the Pacific Northwest, so no distribution system was developed to provide the information to the local fishing community.

The lack of temperature information off the Pacific Northwest led SOSU to the idea that it should develop its own chart, concentrating specifically on those waters. The unit's location in Seattle was ideal for a close and more detailed look at the temperature structure of the ocean in that area and for distributing this information to the Northwest fishermen.

"We received considerable encouragement and assistance from Larry Breaker, oceanographer at NESS' Redwood City Station." Anderson said. Breaker had developed a program of analyzing satellite images and providing ocean frontal locations, mainly to California fishermen through Fred Jurick, Marine Field Agent at Arcata. Both Breaker and Jurick cooperated extensively with SOSU in the development of a program in the Pacific Northwest to serve the north coast fishermen.

In March of 1977, Anderson made another trip to the Washington coast, this time accompanied by oceanographer Kent Short. They participated in two workshops for fishermen at Ilwaco and Westport. These workshops were conducted in cooperation with Sea Grant Field Agents Don Samuelson of Grays Harbor College, Aberdeen, Washington, and Jurick, who is from Humboldt State University, California. During the workshops they discussed the nature of satellite imagery, sea surface temperature analysis and the relationships between coastal upwelling and temperature boundaries.

The fishermen were asked what information and features they thought should be shown on the charts, and expressed a strong desire that the chart grid consist of LORAN-A navigation lines, since that system was used by the majority for positioning.

Anderson and Short also stressed the importance of "feedback" information, asking fishermen to report to SOSU their observations of sea surface temperatures in near real-time. This, they pointed out, would increase the data base, and improve the accuracy of the charts to be produced. While most of the fishermen were receptive to this idea, some expressed concern in disclosing their location, an important consideration in a very competitive business. The suggestion was also made that a tollfree number be established to permit reporting of observations.

With the benefits of the suggestions made at the seminars in mind during the spring of 1977, Short helped SOSU prepare for the upcoming fishing season.

Several steps were taken. The basic chart was designed covering the coastal waters from Vancouver Island in the north to Cape Blanco on the south. A telephone copying machine was installed and contact made with two offices on the coast which also are equipped with telecopiers. These were the Washington Department of Fisheries in Aberdeen, Washington, and Bumble Bee Seafoods in Astoria, Oregon. Both offices agreed to receive the charts, make copies, and aid in their distributions.

"We got a lot of help on this from Brian Culver of the Washington Department of Fisheries, Marine Extension agent Daniel Bergeron in Astoria, Oregon, and Fred Jurick," Short said.

SOSU also put together a special mailing list for the charts, including those fishermen who had attended the workshops, Sea Grant bulletin boards, and various fishermen's associations and charter companies. Arrangements were made for a regular daily schedule of receiving enhanced infrared satellite images from the NESS Field Station in Redwood city, California, over existing telephone line and automatic photo developing machine.

Finally, the unit experimentally analyzed sea surface temperatures plotted from observations furnished by ships in the area. It was found that about three days of observations had to be plotted to arrive at a reasonable data field. The first "chart" was produced at the end of April 1977. Subsequent charts were issued whenever the unit obtained a usable satellite image which showed significantly different thermal boundaries. This averaged out to about once a week.

When persistent clouds blocked the satellite's view of the sea, charts based on shop reports alone were issued.

The unit works closely with Don Olson of the Seattle Port Meteorological Office, which is collocated with the Weather Service Forecast Office. Olson works with ships that take weather observations, visiting them when they call on Washington State ports. This liaison is crucial to continuing the flow of both weather and ocean temperature observations into the Weather Service system and on to SOSU. These ship reports form the main basis of gauging the strength of weather systems at sea

and become the sole data source for the ocean thermal boundary analyses during periods of extended cloudiness.

Maintaining a continuing flow of reliable observations of weather and sea conditions along the shores of the state is most important for input to the local marine forecasts. Meteorologist Bill Burton regularly monitors these reports for quality control and annually visits the manned Coast Guard Stations in the State to assist the personnel on watch, who make and transmit the observations.

A newer source of observations is the growing network of NOAA ocean buoys. Reports from these buoys provide an excellent indication of trends of weather changes at relatively fixed locations off the coast and the spectral wave data from several of the buoys is especially useful in the development of improved forecasting techniques, such as harbor bar conditions. Since buoy reporting is still some what in the developmental stage and also since the hardware is exposed to a harsh environment, problems are to be expected. Burton maintains frequent liaison with NOAA Data Buoy Office personnel both on quality and timeliness of communication of buoy observations.

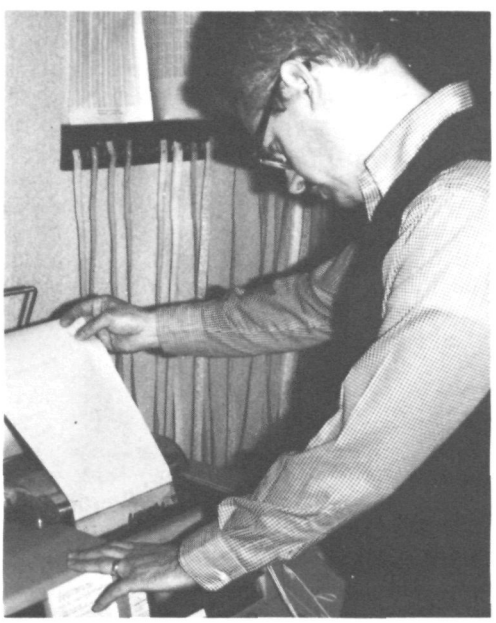
SOSU's next step was to involve other members of the marine services and research community in the thermal boundary program. Monthly "Ocean and Marine Weather Discussions" were held in Seattle from June through September at the Seattle Forecast Office and the Pacific Marine Center. Participants included the Sea Use Council, Sea Grant, and the U.S. Coast Guard, as well as representatives of the National Weather Service from Seattle and Portland, the National Marine Fisheries Service, the National Ocean Survey, National Environmental Satellite Service, and the Pacific Marine Environmental Laboratory. In addition, two Polish scientists from the research vessel Professor Siedlecki attended one meeting.

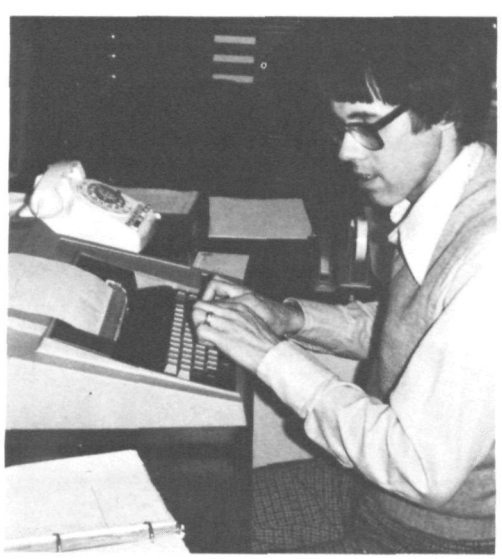
Near the conclusion of the first year's effort, a questionnaire was sent to members of the marine community. In addition to some 57 individuals on the unit's mailing list, the Sea Grant Advisory Office at Grays Harbor College published the questionnaire in its newsletter "Harbor Tides," which goes to almost 2,000 members of the marine community. The informal survey indicated that the service was considered to be useful and accurate. There was also a strong indication of a desire to have the program continued.

In 1978, during the second year of operations of the Thermal Boundary Program, efforts were undertaken to expand the area of coverage while making the charts more readable. In coordination with Ernie Daghir of NESS, the number of lines representing the LORAN-A grid was reduced. Also, through the cooperation of NESS and the Weather Service in Redwood City, California, the Charts were sent by radio facsimile broadcasts out of the Coast Guard Station at Point Reyes, California. NESS staffers in Redwood City received the analysis via telecopier from Seattle, retraced it to larger scale, and transmitted it to Point Reyes. This cooperative effort played a key role in providing the service to more individuals.

During 1978 the Thermal Boundary Analysis Service grew dramatically, and now goes to people in seafood companies, other government agencies, and universities and research institutions, as well as a growing number of fishermen. An additional telecopier was located at Brookings, Oregon, adding to those already established the year before. Distribution in 1978 was again aided by cooperation from Sea Grant and Washington Department of Fisheries personnel.

Twenty-five charts were distributed during the 1978 salmon/albacore season. The average





KUDOS For SOSU

Users of SOSU's products have praised the unit's efforts to provide better and more useful weather services.

Daniel Bergeron, Marine Extension Agent for Oregon State University, wrote concerning the Thermal Boundary Program: "I would like to express my appreciation for the sea surface temperature charts your group has been providing to fishermen. The chart is received in Astoria by Bumble Bee Seafoods, who immediately call me. I pick up a copy and make 75–100 duplicates and distribute them to all fish plants and fishermen who may be interested in tuna or salmon. They are in the hands of the fishermen a few hours after being received here in Astoria."

Frosty's Charters, which takes tuna fishermen out from Ilwaco, Washington, wrote: "We made extensive use of your new service . . . this summer and to great advantage. Hopefully the service will continue because for one thing it puts us on top of fish faster and thereby saves fuel in the process. We can't imagine working in forthcoming seasons without that information."

The NOAA ship Discoverer reported: "The 3-day extended outlooks issued by SOSU along with their real-time weather observations . . . proved extremely valuable in planning operations during the very stormy period of Leg III. Without this special source of information, much less production would have resulted."

Capt. Gary M. Graham, Manager of Marine Operations for the Crowley Maritime Corporation, wrote: "The daily exchange of meteorological forecasts, prevailing weather, and ice reports with your staff has proved of great value to this office. Through the above service, we are able to isolate areas of major interest between the Gulf of Alaska, Bering Sea and Arctic Ocean that are of day-to-day concern."

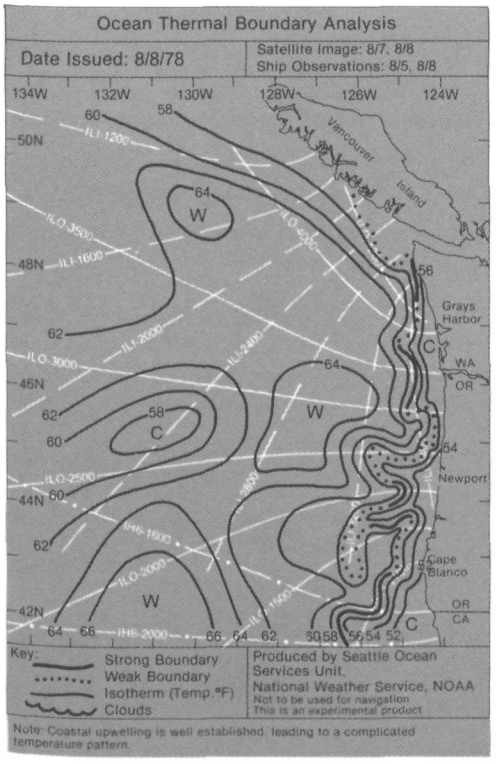
And Vaughn A. Sherman, Commander of Coast Guard Auxiliary Flotilla 12 in Lynnwood, Wash., wrote of lectures given by SOSU staff to his unit: "In the memory of our flotilla members, the donations your service has made to our present course are the best we have ever received." □

was approximately one each week. On those occasions when clear weather prevailed for several days, more than one chart was issued.

Also during the year, SOSU continued its efforts to communicate with the individuals and organizations using their services. Members of the unit participated in the Third Annual Marine Technical Conference sponsored by Washington Sea Grant and attended several seminars concerning fishing techniques and the problems relating to modern commercial fishing. These efforts help to give them a better understanding of the needs and problems of the fishing community.

Fish that are influenced by ocean surface temperatures likely are affected by temperatures to some depth below the surface. Ship observations of subsurface temperatures are collected by the Ocean Services Development Group of the National Meteorological Center and forwarded to SOSU. At the present time, however, these observations are regarded as too sparse for the development of operational subsurface temperature analyses.

Combining the fields of meteorology and oceanography, the unit's experimental projects are unique in the operations of the National Weather Service. The staffers see their mission of providing "ocean weather" information to all potential users as a major responsibility. Perhaps that is best described in the words of unit Chief Bob Anderson, "The word 'service' is a key element in our title. We hope to match up the needs of the mariner for environmental information with advances in technology by developing useful new services." □



A Major Summer Killer

Heat Wave

By CARL A. POSEY

Heat kills by taxing the human body beyond its abilities. In a normal year, about 175 Americans succumb to the demands of summer heat. Among the large continental family of natural hazards, only the cold of winter—not lightning, hurricanes, tornadoes, floods, or earthquakes—takes a greater toll.

Heat waves, those seemingly anomalous intervals of unrelieved high temperatures, amplify these figures tragically. In the 40-year period from 1936 through 1975, nearly 20,000 people were killed in the United States by the effects of heat and solar radiation. The 4,678 heat deaths in 1936, the 1,401 in 1952, and 978 in 1954, and some 10 years with fatalities more than triple the normal-year average, raise the 40-year annual average heat-death toll to 500, a high price to pay for warm weather.

And these are the direct casualties. No one can know how many deaths are advanced by heat-wave weather—how many diseased or aging hearts surrender that under better conditions would have continued functioning.

North American summers are hot; most summers see heat waves in one section or another of the United States. East of the Rockies, they tend to combine both high temperature and high humidity, although the worst have been catastrophically dry.

Lon Burks, an observer at the National Weather Service office in Wichita Falls, Tex., told how it was in July 1978.

"I worked the afternoon shift one week, and it had been above a hundred degrees for days. On July 15, on my way to work, I saw a lot of overheated cars pulled up at gas stations. I didn't think it was that much hotter—but it went up to 114 degrees that day."

The north Texas heat wave last year followed the worst winter of record with the hottest summer. "It began early, in late May, and lasted well into July," said Burks. "We had 25 consecutive days with temperatures of 100 degrees or better, and we would have had more, except that June 27 only got up to 99." In all, Wichita Falls had a total of 53 days with temperatures of at least 100 degrees. From July 3 to 14, daily maximum temperatures ranged from 104 to 108 degrees. "It was unbearable to go outside."

Historically, the big ones include hot summers like that of 1830, which scorched the north central interior, and 1860, which dried up the Great Plains. July 1901 may still be talked about by a few old timers in the Middle West, remembering high temperatures, or thinking about someone the heat killed—there were 9,508 heat deaths in that year.

There is nothing in American climatological annals to touch the heat waves that came with the Dust Bowl droughts of the 1930's. The years 1930, 1934, and 1936 brought progressively more severe summer weather. Record highs of 121 degrees in North Dakota, Oklahoma, Arkansas, and Texas were observed in the ugly summer of 1936; July and August of that year saw record highs of 109 degrees or better tied or broken in Indiana, Louisiana, Maryland, Michigan, Minnesota, Nebraska, New Jersey, Pennsylvania, West Virginia, and Wiconsin.

These were cruel years in terms of heat deaths. From 1930 through 1936, ranging from a low of 678 deaths in 1932 to 4,768 in 1936, heat killed nearly 15,000 persons. The toll is consistently high, but turns sharply upward with increases in average July temperatures. This relationship between excessive July heat and significant jumps in heat deaths persists to the present day, despite the softening effects of modern consumer technology.

Because of this relationship, one can detect years in which heat waves occurred by looking at either July-August average temperatures or the number of deaths in the excessive heat category.

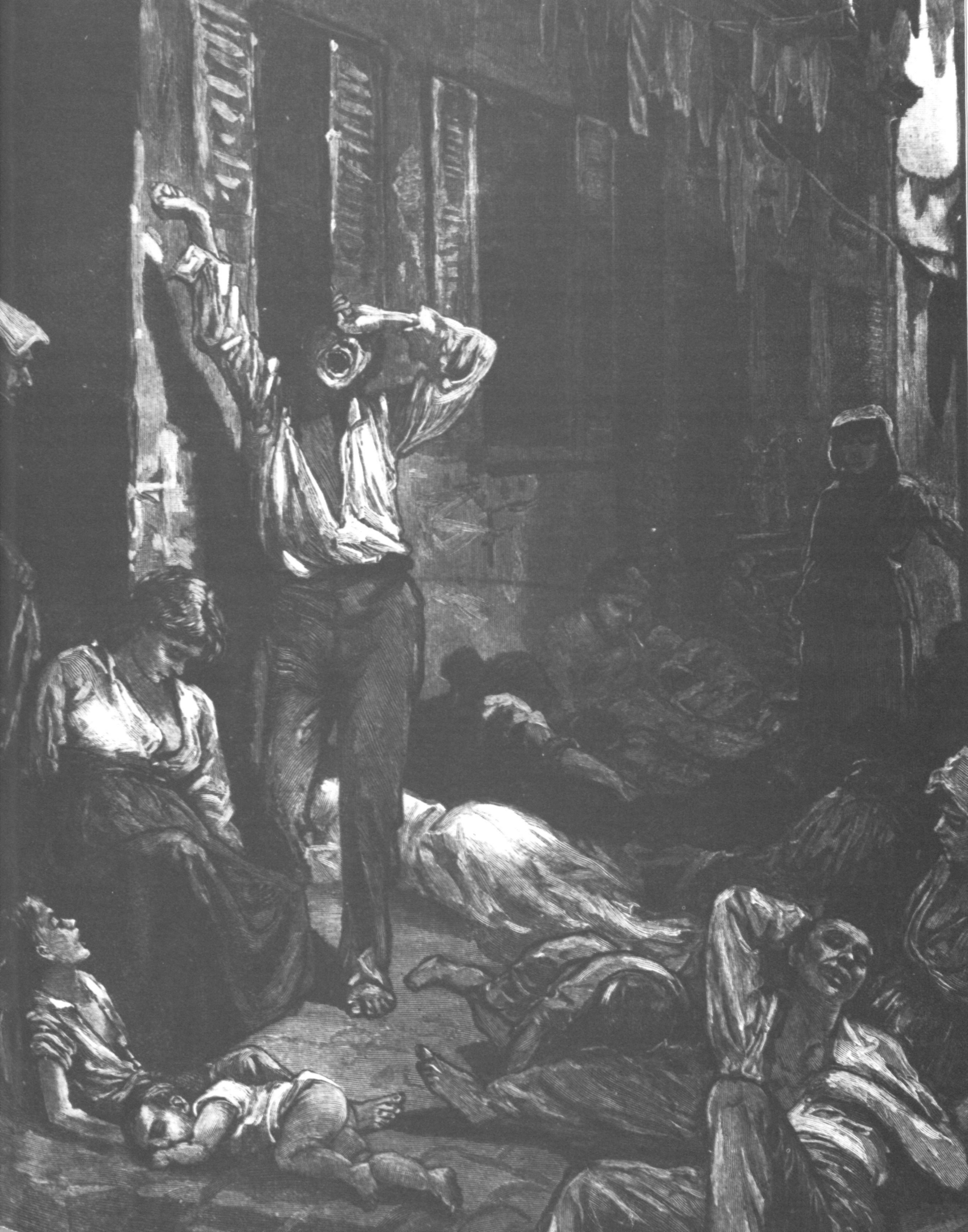
The heat wave of July 1966, perhaps the best-documented case to date of how mortality and meteorology connect in a hot summer, covered much of the eastern and middle United States with high temperatures and very high humidity. The statistical portrait of this heat wave demonstrates its profound, and complicated, effects on human life.

Hot weather was the primary cause of 246 deaths in St. Louis, Mo., and a strong contributor to 40 more. But the indirect casualties were still more appalling. From Oklahoma eastward, normal mortality rates nearly doubled during the period of extreme high temperatures, and increased more than fivefold in the city of St. Louis. A week earlier, a Fourth of July heat wave in New York City more than doubled normal death rates, with mortality statistics resembling those one would expect from an epidemic breakout of fatal cancer and respiratory disorders.

Mammals and birds are homoiotherms—warmblooded creatures who maintain an essentially constant body temperature regardless of their thermal environment.

Human bodies dissipate heat by varying the rate and depth of blood circulation, by losing water through the skin and sweat glands, and, as the last extremity is reached, by panting. Under normal conditions, these reflex activities are kept in balance and controlled by

Photo: National Library of Medicine



the brain's hypothalamus, a comparatively simple sensor of rising and falling environmental temperatures, but a sophisticated manager of temperatures inside.

A surge of blood heated above 98.6 degrees sends the hypothalamus into action. The heart begins to pump more blood, blood vessels dilate to accommodate the increased flow, and the bundles of tiny capillaries threading through the upper layers of skin are put into operation. The body's blood is circulated closer to the skin's surface, and excess heat drains off into the cooler atmosphere. At the same time, water diffuses through the skin as insensible perspiration, so-called because it evaporates before it becomes visible, and the skin seems dry to the touch.

If the hypothalamus continues to sense overheating, it calls upon the millions of sweat glands which perforate the outer layer of our skin. These tiny glands can shed great quantities of water (and heat) in what is called sensible perspiration, or sweating. Between sweating and insensible perspiration, the skin handles about 90 percent of the body's heat-dissipating function.

As environmental temperature approaches normal body temperature, physical discomfort is replaced by physical danger. The body loses its ability to get rid of heat through the circulatory system because there is no heat-drawing drop in temperature between the skin and the surrounding air. At this point, the skin's elimination of heat by sweating becomes virtually the only means of maintaining constant temperature. Now it is not the heat but the humidity, as they say.

Sweating, by itself, does nothing to cool the body, unless the water is removed by evaporation—and high relative humidity retards evaporation. Under conditions of high temperature (above 90 degrees) and high relative humidity (above 75 percent), the body is doing everything it can to maintain 98.6 inside. The heart is pumping a torrent of blood through dilated circulatory vessels; the sweat glands are pouring liquids—and essential dissolved chemicals, like sodium and chloride—onto the surface of the skin. And the body's metabolic heat production goes on, down in the vital organs.

But the thermal limits are there. When they are exceeded by very much or for very long, the warmblooded organism does not doze, reptile-fashtion. It dies.

A NOAA-EPA study of the effect of temperature on mortality rates is revealing. During a New York City heat wave in July 1966, temperatures and mortality ascended together, with the death rate increasing to 2.39 times the normal death rate one day after the maximum temperature, 103 degrees, was observed. A closer look at this heat wave death rate shows major jumps in deaths due to cancer, stroke, atherosclerotic and hypertensive heart, and influenza and pneumonia. In some cases, the sudden increase looks like an epidemic: a near-normal 43 cancer deaths on Friday increased to 98 by Monday, and 88 atherosclerotic heart fatalities rose to 230 over the same period.

For people with heart disease, climatic stress is worse than for others. In a hot, humid environment, impaired evaporation and water loss hamper thermal regulation, while physical exertion and heart failure increase the body's rate of heat production. The ensuing cycle is vicious in the extreme.

Photos: Jim Goodlin

Above: Light clothing and a light diet help to keep your body temperature normal.
Right: Plenty of water helps prevent your body from drying out during the hot spell.

A study of three September heat waves in Los Angeles and Orange County, Calif., shows what excessive temperature alone can do, without the complicating factors of high humidity or air pollution. In each case, the heat waves were accompanied by an increased mortality, especially among the elderly.

The California study agreed with other researchers that increased mortality in a heat wave tends to follow maximum temperatures by about one day—the day it takes to overwork a tired circulatory system. The causes of "extra" deaths in September 1963 would seem to bear this out. Most were assigned to coronary and cerebrovascular disease. Although heat syndrome was almost absent as an immediate cause of death and not emphasized in health statistics, it was clearly an underlying cause of death.

In the far Southwest, heat waves are children of the desert, occasional intrusions of warm air that make the mild sea-cooled California climate more like that of Agadir. Sometimes they are general and persistent, like those which gave the area very hot summers from 1955 through 1961.

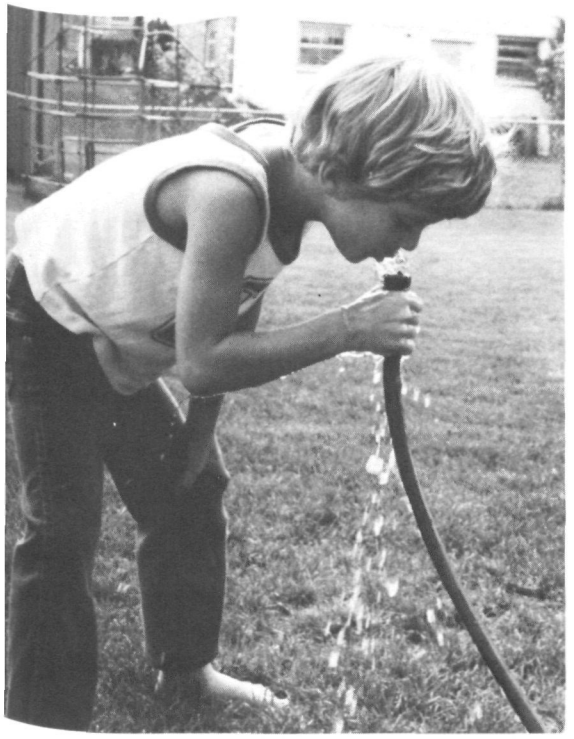
But California's worst heat waves ride in on "those hot dry Santa Anas that come down through the mountain passes and curl your hair and make your nerves jump and your skin itch."*

Produced when a high over the Nevada desert sends its compression-heated, sand-warmed currents of descending air southwestward, the Santa Anas boom into the Los Angeles basin late in the summer season, usually in September, bringing air that is almost too hot and dry to be inhaled. Santa Ana heat waves in 1939, 1955, and 1963 lasted a few days, brought maximum temperatures of 100–110 degrees and, like heat waves anywhere, pushed mortality rates upward.

The red winds that struck southern California in November 1969 brought the lowest average humidity since January 1960, and blew as high as 78 miles an hour through mountain passes. Meteorologists remember the classic Santa Ana of September 1970 as a major outbreak, with temperatures soaring from the Mexican border to Santa Barbara, and one of the worst fire disasters of record for Los Angeles county: the maximum of 105 degrees on September 27 was the hottest day in seven years.

But red winds heat up the Pacific state almost every year. In September 1978, a Santa Ana drove maximum temperatures in Long Beach to 106 two days running, and Los Angeles, with four days over 100 degrees, saw a maximum of 107 on September 25.

* *Chandler, Raymond, "Red Wind," The Simple Art of Murder, Houghton Mifflin, Boston, Copyright 1950; used with permission.*



Heat syndrome* refers to several clinically recognizable disturbances of the human thermoregulatory system. The disorders generally have to do with a reduction or collapse of the body's ability to shed heat by circulatory changes and sweating, or a chemical (salt) imbalance caused by too much sweating. Ranging in severity from the vague malaise of heat asthenia to the extremely lethal heatstroke, heat syndrome disorders share one common feature: the individual has overexposed or overexercised for his age and physical condition in the existing thermal environment.

Sunburn, while not categorized as heat syndrome, is pertinent here, for ultraviolet radiation burns can significantly retard the skin's ability to shed excessive heat.

Studies of heat syndrome and its victims indicate that, other things being equal, the severity of the disorder tends to increase with age—heat cramps in a 17-year-old may be heat exhaustion in someone 40, and heat stroke in a person over 60.

Acclimatization has to do with adjusting sweat-salt concentrations, among other things. This concentration changes from winter to summer just as it does when one moves from Boston to Panama. The idea is to lose enough water to regulate body temperature, with the least possible chemical disturbance. Because females appear to be better at this than males—females excrete less sweat and so less salt—heat syndrome is more punishing to males.

But being acclimated carries other apparent benefits. During the July 1978 heat wave in north central Texas, where by some standards every summer is a heat wave, 25 deaths were attributed to excessive heat, none of them in Wichita Falls. But death rates from cancer, heart disease, cerebrovascular disease, influenza, and pneumonia showed essentially no change from the same figures for 1977. While not conclusive, these figures suggest that the Texas summer has trained people to survive heat waves rather well.

The high inner-city death rates for St. Louis in 1966 can also be read as poor access to air-conditioned rooms. While air-conditioning may be a luxury in normal times, it can be lifesaver during heat wave conditions.

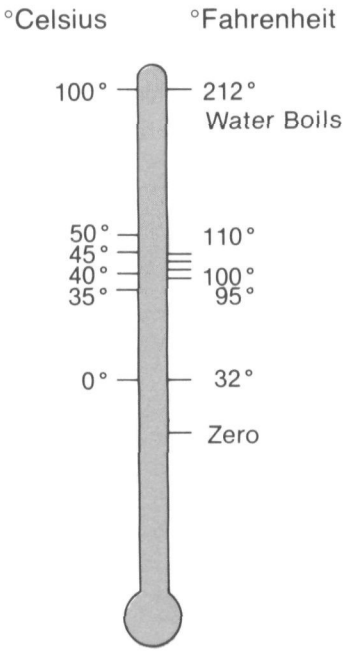
The cost of cool air moves steadily higher, adding what appears to be a cruel economic side to heat wave fatalities. Preliminary indications from the 1978 Texas heat wave suggest that some elderly people on fixed incomes, many of them in buildings that cannot be ventilated without air conditioning, found the cost too high, turned off their units, and ultimately succumbed to the stresses of heat syndrome.

Judged against even the most destructive atmospheric phenomena, heat wave weather is an ill wind indeed. □

Burch, G., and Depasquale, N., "Hot Climates, Man and His Heart," Thomas Brooks, Springfield, (Ill.) 1962. Much of the information on the human thermoregulatory system and heat syndrome comes from this definitive work. Copyright 1962 by Charles C. Thomas, Publisher; used with permission.

How Hot is Hot in Metric?

Everyone understands the scorching temperatures recorded by NWS and related in the story. If you find yourself in a heat wave in a metric country, here's how hot you will be:



There is another relationship between life and heat wave weather that scientists are just beginning to comprehend. The stagnant atmospheric conditions of the heat wave trap pollutants in urban areas and add the stresses of severe pollution to the already dangerous stresses of hot weather, creating a health problem of undiscovered dimensions. A map of heat-related deaths in St. Louis during 1966, for example, shows a heavier concentration in the crowded alleys and towers of the inner city, where air quality would also be low during a heat wave.

There is still insufficient knowledge to identify the casualties of pollution. Work by NOAA and the Environmental Protection Agency suggests that temperature is a key element in assessing mortality rates.

Research now underway will add other apparently crucial meteorological and air-quality values to the mortality figures, to illuminate further the linkage between human life and environmental quality.

Heat Wave Safety Rules

Slow down. Your body can't do its best in high temperatures and humidities, and might do its worst.

Heed your body's early warnings that heat syndrome is on the way. Reduce your level of activity immediately and get to a cooler environment.

Dress for summer. Lightweight, light-colored clothing reflects heat and sunlight, and helps your body maintain normal temperature.

Put less fuel on your inner fires. Foods (like proteins) that increase metabolic heat production also increase water loss.

Don't dry out. Heat wave weather can wring you out before you know it. Drink plenty of water while the hot spell lasts.

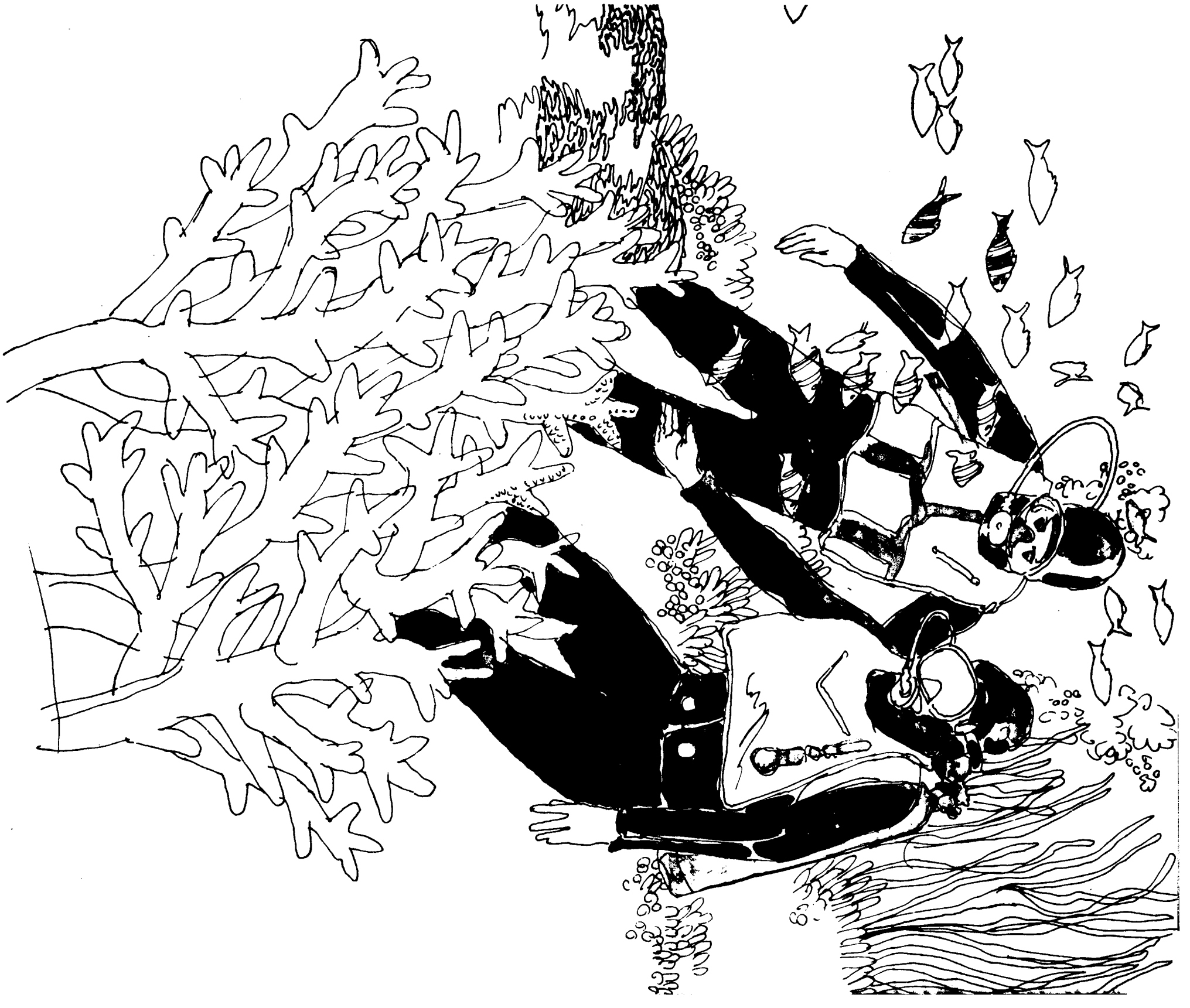
Stay salty. Unless you're on a salt-restricted diet, increase your salt intake when you've worked up a heavy sweat. (But remember that the American diet tends to be heavy on salt; many people can get adequate salt during hot weather from their normal diet, or from just a slight increase in salt intake.)

Avoid thermal shock. Acclimatize yourself gradually to warmer weather. Treat yourself extra gently for those first critical two or three hot days.

Get out of the heat for at least a few hours each day. Physical stress increases with exposure time in heat wave weather. Drop in on a cool store, restaurant, or theater—anything to keep your exposure time down.

Don't get too much sun. Sunburn makes the job of heat dissipation that much more difficult.

Know these heat syndrome symptoms and first aid.



Safe Diving—Passport To A New World

There is something powerfully compelling about the silent, mysterious world beneath the surface of the sea. It is strange yet beautiful, a kaleidoscope of multicolored, often breathtaking images; a slow-motion world filled with brilliantly hued fish and exotic creatures. It is like an uncharted continent, a weightless frontier where gravity seems suspended. It is a place that combines the challenge of the unknown, exhilaration and adventure, fascination and awe, complete relaxation and solitude—a place to forget totally the cares of the outside world.

Whatever the lure, more than two million Americans have already been drawn to the sport of scuba diving. And that number is growing by nearly a quarter million enthusiasts each year. Diving has become a safe and sane sport that the entire family can enjoy.

The cost is modest. Equipment has become sufficiently adaptable for most people to use with no problem. And almost anyone in good physical condition can participate. Of course, a prospective diver should swim fairly well and feel comfortable in the water. Some skin-diving experience helps, but is not necessary.

What is absolutely necessary is a thorough course of diving instruction taught by a certified instructor. For the untrained, the underwater environment can be hazardous. For the well-schooled newcomer, however, one who has learned the equipment, and the basic diving skills and procedures, scuba is safe and fun. A number of organizations offer good courses for beginners—the YMCA, the National Association of Underwater Instructors, the National Association of Skin Diving Schools, the Professional Association of Diving Instructors, and Scuba Schools International. With practice (in shallow water or a swimming pool), the new diver will become more confident and relaxed—and ready to enjoy fully the unique wonders and satisfactions of the underwater world.

Even with the best training, safe diving requires common sense. You should never dive by yourself. You should be in good physical shape. If you are not feeling well, you should not dive. Never consume alcohol or take other stimulants before diving. Always be realistically objective about your physical abilities and diving skills. Use good judgment in deciding where and when you will dive. And never take chances. Finally, check your equipment often, always keeping it in good working order. These, and the following more detailed commonsense rules, should be heeded by all divers, regardless of experience.

A Safety Check-List for Divers

Before the Dive

- Make certain you are familiar with the prospective diving site—currents, visibility, tides, access, bottom conditions, and so on. Is the area suitable for your level of skills?
- Carefully plan your dive, including duration, depth, and distance. Again, are you experienced enough to make the planned dive?
- Make sure you are thoroughly familiar with your equipment. Is it right for the kind of diving planned? Is it in perfect operating condition?
- Check on where local diver and medical assistance is available in case of emergency—lifeguard service, fire and police departments, harbor patrol, the nearest recompression chamber.
- Before a dive, you should be in good health, well rested, mentally prepared, and able to equalize underwater pressures (you should not be suffering from any respiratory infections).
- Review with your fellow divers the diving plan as well as emergency procedures and signals.

During the Dive

- Objectively assess water, wind, and weather conditions at the diving site, making an honest "go" or "no go" decision based on your skills.
- Never dive alone. Always dive with a "buddy." His or her presence could be critical in an emergency.
- Before entering the water, check once more on your air supply, your gear adjustment, your weight belt quick release, and your buoyancy compensator (always wear a buoyancy device).
- Enter the water with your fellow divers and put out a "diver down" flag in the area where you are diving.
- Ascend and descend together with your partner. Stay abreast of your partner underwater and maintain contact. Know the basic hand signals so that you can communicate with each other.
- Equalize on your descent and establish neutral buoyancy when you reach your diving depth (adjusting your buoyancy compensator as necessary).
- Follow your dive plan—duration, depth, and direction.
- Signal your buddy before changing direction, or swimming up and down. If separated, wait briefly for buddy's arrival, then ascend slightly, looking for bubbles. If buddy is not sighted in less than one minute ascend to the surface and wait for buddy to do the same. Immediate effort should be made to relocate buddy since he or she may be in difficulty.
- Frequently check your air supply and keep track of time.
- Always keep an adequate air reserve at the end of your dive.
- Ascend at the proper rate of speed, according to the Navy Diving Manual or the NOAA Diving Manual.
- Always exhale and equalize while ascending.
- After surfacing, inflate your buoyancy device and return to shore (or your boat) at a slow, relaxed pace.

After the Dive

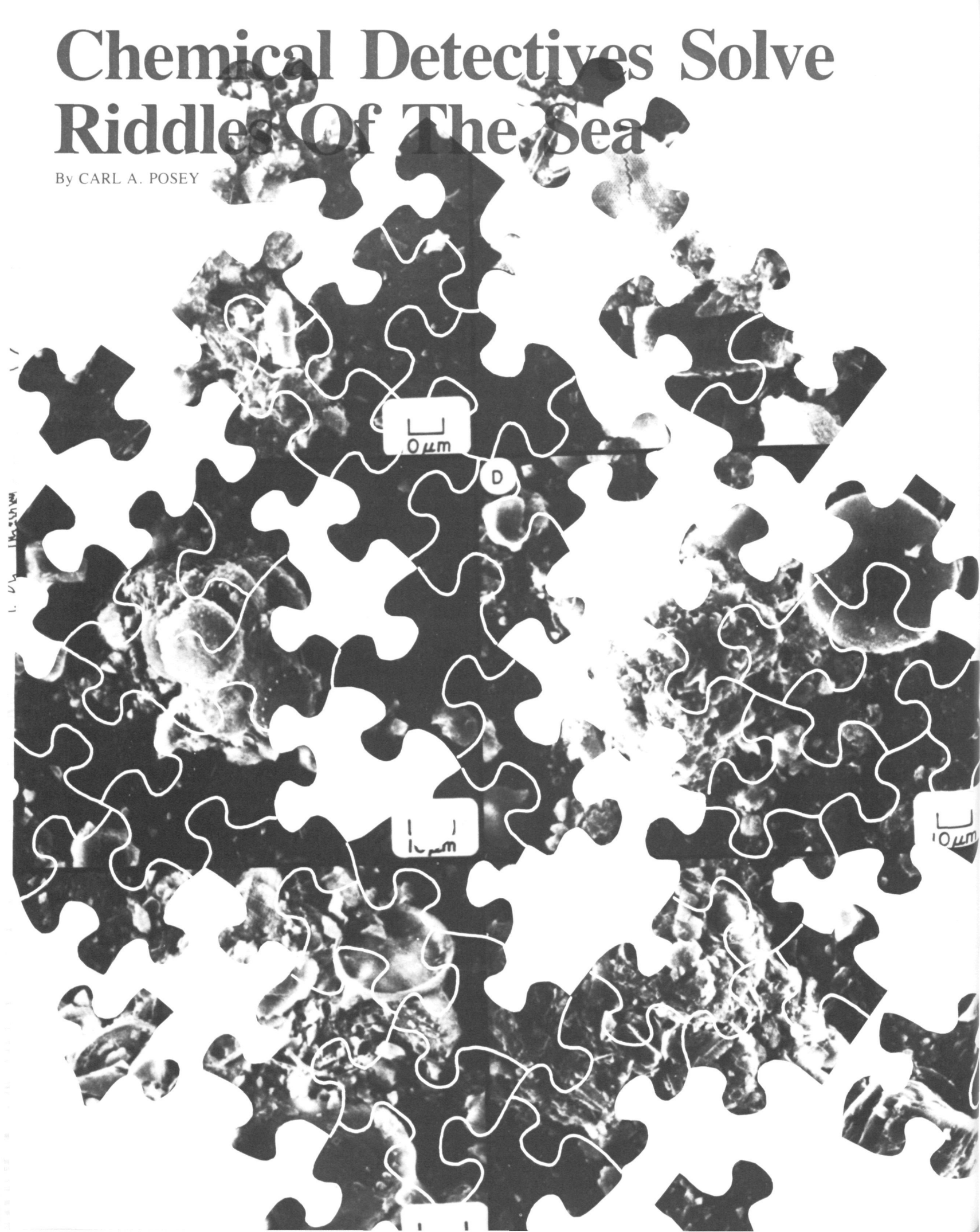
- Be alert to any physical symptoms of the bends such as a rash, dizziness, pains, or slight nausea. Even a slight case of the bends, if ignored, can intensify and be dangerous.
- Rest before diving again, checking your diving table for proper intervals.
- After diving, record your depth and underwater time. Then rinse, dry and store your equipment.

Special Diving Precautions

- Never dive if you are suffering from any kind of respiratory condition. Diving with a head cold can result in a ruptured eardrum, while diving with a chest cold can lead to a dangerous embolism.
- Avoid both alcohol and drugs before diving. Because of the physiological effects of pressure on the body, alcohol and drugs have different effects underwater from on the surface. Alcohol, barbiturates, tranquilizers, narcotics, hallucinogens, amphetamines (and even smoking) can affect your reactions and judgment and make you more susceptible to the bends, nitrogen narcosis and other physical problems.
- Do not use decongestants and nose sprays before diving. They wear off quickly underwater, increasing the danger of "reverse block" when ascending.
- Women who are pregnant should not dive. Research indicates that a fetus is much more susceptible to decompression sickness (the bends) than an adult mother. Thus, pregnant women run the risk of harming their unborn babies if they dive. □

Chemical Detectives Solve Riddles Of The Sea

By CARL A. POSEY



The water samples hauled aboard the NOAA ship Researcher seem routine, little different from samples taken by oceanographers across the world ocean. Those taken on this February day in 1978 come from the Sargasso Sea, the southwestern corner of the North Atlantic where oceanographers have found, instead of the legendary graveyard of seaweed-entrapped ships, a storehouse of thermal energy that feeds the Gulf Stream. The sampling was part of an effort to trace the migration of Sargasso Sea water (and energy and pollutants) into the Caribbean, around past Yucatan, and across the Gulf of Mexico to the Florida Straits.

Dr. George Harvey's chemical analysis, however, showed that the Sargasso Sea samples, recovered from a depth of 250 meters, contain an unexpected oily substance. Based on the amount of water recovered, it appears that the oily substance occurs in dissolved concentrations of from 2 to 12 milligrams per liter, quantities far above the open ocean's normal dissolved organic concentration of less than 1 milligram per liter. Moreover, the material is not just any organic substance—it consists mostly of a family of compounds called hydrocarbons, which make up the complex mixture of compounds in petroleum. "Normal" ocean water hydrocarbons are usually only about 10 percent of total organic matter. On shore, still more analysis of the material indicates that it resembles weathered crude oil. It must have a petroleum source, possibly a large natural oil seep in the seafloor.

Finding an underwater "oil slick" in the open ocean is like finding a body in a locked room: the discovery is only the beginning, a reason to bring detectives in. Only 10 years or so ago, no one aboard the Researcher would have detected the "body," the subsequent investigation would not have begun, and an opportunity to develop significant new insights into how the ocean handles oil would have been lost.

What has changed?

The difference is that oceanography today is as concerned with the chemistry of the sea as with its temperature, salinity, motion, and other geophysical properties. The field of chemical oceanography has visibly come of age.

Following World War II, the geophysical side of oceanography was greatly invigorated by an infusion of antisubmarine warfare research money from the Navy. Except for some Navy-funded projects on marine corrosion and underwater chemical sniffing for submarines, this healthy flow of money bypassed the ocean chemistry community.

But their opportunity was on the horizon, in the form of intense public concern for the effects of humans on their global home. Over the decades of the 1960's and 1970's, this environmental impetus has been to ocean chemistry what the naval support was to the other oceanographic disciplines. As Dr. Herbert Curl, who leads the biology/chemistry work at NOAA's Pacific Marine Environmental Laboratory in Seattle, put it: "Both pushes occurred for very practical reasons."

In NOAA, the first strong move toward developing a capability in chemical oceanography came from the refocusing of some of the agency's oceanic programs on pollution problems in the marine environment, notably the waters off the New York-New Jersey coast. Capt. Lawrence Swanson, former manager of the Marine Ecosystems Analysis (MESA) New York Bight Project and present director of the newly formed Office of Marine Pollution Assessment, remembers that his project made the first ocean chemist positions available at the Atlantic Oceanographic and Meteorological Laboratories in Miami. "You don't go very far into an environmental study without realizing you're going to need a chemist," he said.

Since then, the Miami contingent of chemical oceanographers has grown to about an $800,000-a-year effort involving a score of people, housed in an Ocean Chemistry Laboratory directed by Dr. Donald Atwood. Meanwhile, chemical/biological efforts of about the same size and weight were beginning at two other NOAA marine research facilities, the Pacific Marine Environmental Laboratory's effort led by Curl and the Great Lakes Environmental Research Laboratory's group led by Dr. Andrew Robertson. All three came to NOAA from academia, Robertson from the University of Oklahoma, Curl from Oregon State, and Atwood from the University of Puerto Rico.

Chemical oceanography begins in the world of classical oceanography, where chemists use more or less traditional tools to sample sea water and take sediments from the ocean floor. But there the similarity ends. For ocean chemistry takes scientists to a submicroscopic world of molecules and bonding energies, complex exchanges between the fundamental particles of matter and the fundamental particles of life.

Contamination is an ugly word to ocean chemists because it destroys the value of hard-won samples. Metals are a case in point. "Everybody used to think the mean copper level for the open ocean was about 3 parts per billion," Atwood explained. "It turns out that all the samples were contaminated, and it's really about 5 to 50 parts per trillion. The same thing happened with zinc, lead, cadmium. The early samples were contaminated.

"Contamination is the key problem in ocean chemistry," he said, "so we're always trying to develop ways to get an uncontaminated sample out of the ocean, on board ship, and into a lab. It's always in a state of development. George Harvey builds huge anodized aluminum samplers. Steve Piotrowicz uses a large 10-liter teflon bottle with no metal parts, hung on all-plastic wire, with a means of sealing it off until it gets underwater.

"We don't really have vessels with good chemistry labs. The earlier dream of a chemistry ship with clean rooms, positive pressure chambers, and all that just isn't going to happen. So you develop capabilities that can function on existing ships. We use mainly the Researcher and the Kelez. The Kelez is especially useful because MESA took advantage of her well-deck and designed laboratory vans that can be lifted aboard to fit it.

"The real problem is when you have to do very clean work . . . when you're looking at small quantities of trace organics and metals. We keep trying to overcome this kind of difficulty."

One innovation developed at the Miami laboratory is a radio-controlled boat that takes water samples some distance away from the ship's hull, which adds contamination to ocean water simply because the hull is made of metal. The radio-controlled boat, Atwood noted, derived from Harvey's earlier efforts to collect aerosol samples away from ships using radio-controlled model airplanes.

Once ashore, the ocean chemist's tools run to gas chromatographs, mass spectrometers, and analyses in laboratories that look like laboratories are supposed to look—places with lots of glass tubing, gas burners, devices with which to analyze, extract, reduce, dissolve, count. "There's a lot of basic sample workup," Atwood said. "The basic techniques are about the same as they were 30 years ago, but you have to be more careful now, and the instruments used in final analysis of the worked-up sample are much more sensitive today."

The large quantity of handwork in ocean chemistry, according to Herb Curl in Seattle, makes the field a "data-limited" one. "We don't have black boxes that let us put a probe in the water and read out the chemistry," he said. "That slows down our rate of data collection. Where many fields, such as remote sensing, generate huge quantities of data, we're definitely data limited. But," he added, "I don't think we're theory limited."

This means, for the ocean chemists in Miami and Seattle and their colleagues in Ann Arbor, that there is enough information in hand for them to develop approaches for pursuing the chemical secrets of the ocean and lakes that constitute their research domain.

If the three ocean chemistry efforts in NOAA's Environmental Research Laboratories are united by discipline, they have been shaped by the particular needs of very different environments. In Miami, Atwood's laboratory has focused on the problems of the New York Bight, but conducts deep-water chemistry research as well. The 1978 Researcher cruise, for example, traced a specific water mass—subtropical underwater—from its origins in the Sargasso Sea into the Caribbean. ROME (from Role of Organics in the Marine Environment), a major study of Gulf of Mexico chemistry, is just beginning. "We must find some way to assess and monitor the health of the ocean," Atwood said, describing his lab's central goals. "We have to come up with parameters to use to predict how this health will change, or not change, in response to stresses placed on it."

A biological team in the Miami laboratory works at the lower levels of the oceanic food web, where biology and chemistry shade into one another. The whole matter of organic-inorganic relationships has become an increasingly important element in ocean chemistry. "We used to believe that if you took all the organic material in the ocean," Atwood explained, "it wouldn't affect the trace metal chemistry to any degree. But organic-metal complexing turns out to be an important process there after all, since it affects the toxicity of the metals, and these metal concentrations are much less than we thought. It also turns

out that zinc and cadmium are very closely tied to nutrient concentrations and biological processes. It's now apparent that anthropogenic sources of metals are important. We used to suspect they were. Now it turns out that things like the lead input from automobiles are very important."

Other Miami chemists like Pat Hatcher pioneer new techniques for identifying human impacts on marine ecosystems—techniques like the use of the steroid coprostaonol, formed only in the intestines of mammals, as an indicator of sewage concentrations in coastal areas.

One of the seeming miracles of ocean chemistry is that the chemists can tell one parcel of ocean water from another. But physical oceanographers have already identified most of the water masses in the world, and recorded their signatures of temperature and salinity—signatures given the water masses at the surface. Thus, the need for chemical tracers is minimized. Even Great Lakes water varies enough for chemical oceanographers to discriminate, say, between water from Lake Michigan and water from Superior.

Because water masses have physical signatures, NOAA's marine chemists do not use tracers as often as one might think. But one tracer commonly used is bomb-derived tritium. "Because of past bomb tests, there is an equilibrium of tritium in the atmosphere," Atwood said, "and this dissolves in surface waters. Since tritium decays into helium-3, the ratio of tritium to helium-3 in water samples tells you how long the water's been away from the surface. Chemists can tell this to within a month, using techniques developed by Bill Jenkins at Woods Hole Oceanographic Institution. This allows us to calculate a rate for observed changes in water chemistry."

The younger effort in Seattle carries less theoretical and less deep-water work and perhaps more application in its mission. Funded heavily by NOAA's MESA and Outer Continental Shelf Environmental Assessment Program (OCSEAP), and by pass-through funds from the Environmental Protection Agency, the chemical work is highly focused on the problems of trace metals and hydrocarbons in northwestern and Alaskan coastal waters and estuaries. "We're mainly concerned with the distribution, abundance, and recycling of trace metals, and low-molecular-weight hydrocarbons," said Curl. In hydrocarbon work especially, they have led their field in learning to distinguish between biogenic hydrocarbons caused by natural processes—for example, those given off by plankton—and petroleogenic hydrocarbons from spilled oil.

Their major province of investigation is the sharply sculpted coastlines and estuaries of the American northwest, and the complex northern ecosystems that would be at risk in the event of a major oil spill. Much of their oceanography gets done from the frozen decks of NOAA ships operating in lower Cook Inlet, the Gulf of Alaska, and the Bering and Chukchi Seas.

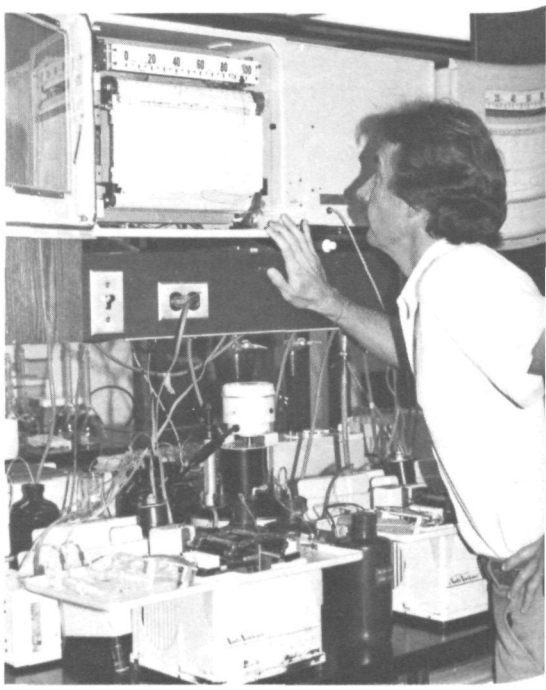
As with the Miami effort, a large part of the activity has to do with learning, or improvising, new ways of doing things. For example, the laboratory has developed a portable mass spectrometer which provides relatively coarse but effective measurements of hydrocarbons in the open ocean. The instrument permits measurements to be made while the research vessel is underway, greatly accelerating the rate at which such information can be acquired at sea, where time is a lot of money.

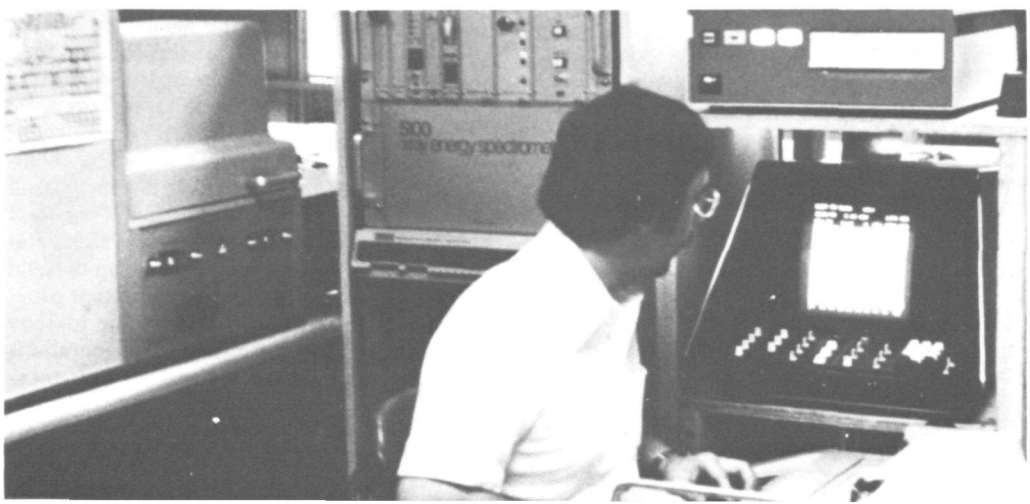
Scientists from the Seattle laboratory also have designed and built self-closing sediment traps which they use to collect particles that fall through the water column. The traps are deployed on moorings and allowed to remain open for specified periods of time. Once the traps have closed, they are retrieved and returned to the laboratory, where particles collected by the traps are analyzed for trace metals. By studying the composition and vertical fluxes of these particulate materials and associated trace metals, the NOAA researchers can determine the rate at which toxic trace metals are removed from the water column and incorporated into the sediments.

Curl, who began as a biological oceanographer doing mostly chemistry, is primarily interested in the functions of the ecosystem and the underlying chemical processes. "We've recently extended our work to include nutrients, or biostimulants, and we're getting more into mass spectrometry, gas chromatography, and the use of radio tracers. But our work is pretty much all mission-oriented, and has to do with the effects of pollutants on biosystems and harvestable organisms."

One new direction taken by the Seattle lab looks at the positive side of the human propensity for dumping material into the sea. "We call our program 'Beneficial Disposal of Wastes in the Ocean," Curl said. "If you have fertilizer going into the ocean, you might as well do some good. From this work we hope to learn at what rate and quantity these disposed materials will have some beneficial effect on the ecosystem."

At Ann Arbor, the chemical work is directed entirely toward solving the problems of the





Clockwise, from top left, Dr. Andrew Robertson, head of the Great Lakes Laboratory's Chemistry/Research group; Dr. Donald Atwood, from NOAA's Atlantic Oceanographic and Meteorological Labs in Miami; and Gary Massoth at the Seattle Lab at Sand Point.

pollution-plagued Great Lakes. "Thus far," explained Dr. Andrew Robertson, who leads the chemical and biological programs there, "we've concentrated our work on the movement within the Great Lakes of nutrients, especially phosphorus. These accelerate the eutrophication process, in which a lake gradually deteriorates in water quality."

Phosphorus enters the lakes from sewers, agricultural drainage, and other sources and fertilizes algae in the lakes. The increase in algae becomes a problem because the organisms die and fall to the bottom, where their decomposition uses up dissolved oxygen needed by other life forms. They also clog intake screens on water treatment plants and accumulate on beaches, and so seem to have their largest environmental impact in areas of immediate concern to humans. The Great Lakes laboratory effort has focused mainly on determining how phosphorus behaves once it enters the lakes, and on its effects and ultimate fate in the ecosystem. To do this, the Ann Arbor effort, like its counterparts in Miami and Seattle, carries out some biological work, principally concerned with planktonic succession—how different types of plankton follow each other seasonally, and how succession is affected by seasonal changes in predators and nutrients.

"The nutrient problem has been with us for the last ten years," Robertson said. "We've seen very large changes in terms of abundance and the types of life forms in the lakes, and some lakes are in worse shape than others—the whole center of Lake Erie goes anoxic every summer, for example."

The problem on the Great Lakes horizon is that of toxic organic materials. "This is a very big environmental problem here, and we are just beginning to work on toxic organics in a serious way. Our preliminary emphasis is on polynuclear aromatic hydrocarbons, which are produced naturally, but which also come from incomplete combustion of hydrocarbons. These materials are carcinogens. We need to learn how much is out there, and the specific sources. We also need to begin looking at polychlorinated biphenyls, or PCB's, which come into the Lakes from industry, and at residual DDT washing in from past agriculture uses. Nutrients are our old problem. Toxic organic chemicals are our new problem."

Robertson sees the Great Lakes as a possible harbinger of things to come in coastal areas. "Because we're so industrialized, and the lakes have so little water in them compared to the ocean, we tend to get the problems sooner than the oceans, and the problems tend to be more severe." They also tend to last longer: inoculate Lake Superior or Lake Michigan with a pollutant and it will stay there for centuries, so meager is the flushing action.

While missions vary, there remain more similarities than differences between NOAA's three marine chemistry efforts. All of them carry out their work along the boundaries and thresholds that define how well this kind of science can be done.

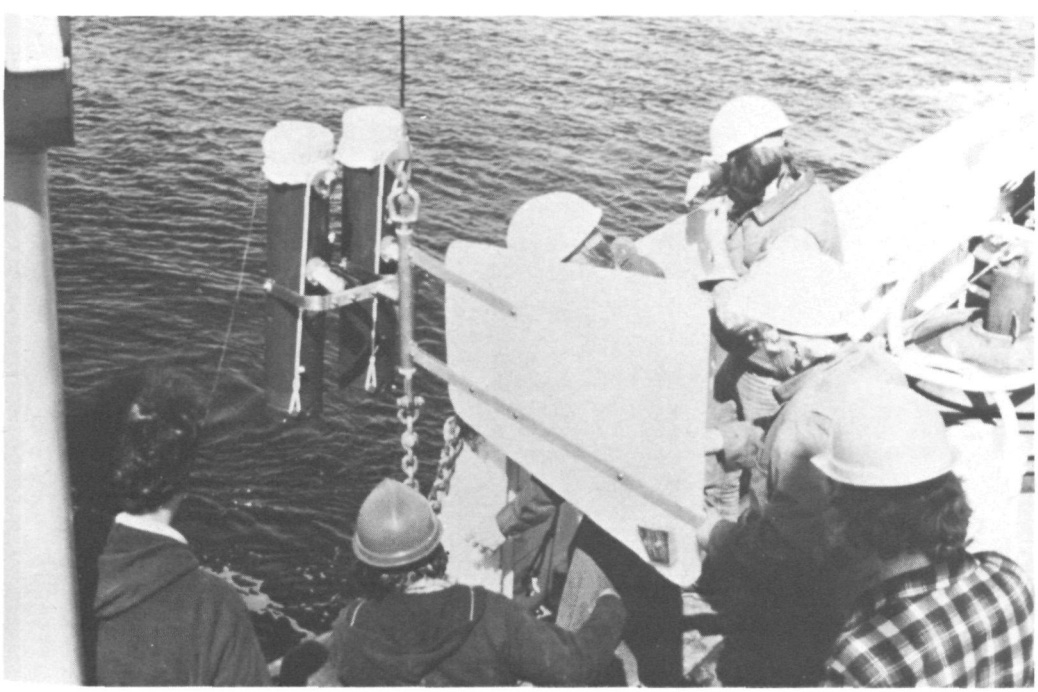
"I think we're working at the state of the art," Curl said. "One of our frontiers is interrelating biological, chemical, and physical processes in the ocean. We have a long way to go on these. We're just beginning to work with the middle trophic levels, to determine the effects of toxicity and biostimulation. This level is almost totally ignored, and is very difficult to study. There's just a lot of ignorance about chemistry in the ocean."

Atwood finds that working at the state of the art means old ground has to be re-covered. "We, and our colleagues in universities are having to re-evaluate old techniques. For example, one of our standard techniques is measuring carbon-14 uptake, which is proportional to carbon uptake, and indicates primary productivity. Today, it's obvious that the presence of trace metals grossly affects your productivity measurements. So Peter Ortner of this lab has had to re-evaluate a technique we've been using with reasonable confidence for 15 years."

What about the field of ocean chemistry itself?

Atwood sees it coming of age, noting that the National Science Foundation's support for ocean chemistry has increased, as has the number of new Ph.D.'s, and that there is no dearth of problems in chemical oceanography to be solved. "There have always been ocean chemists," Atwood said, "but it's always been a relatively small group, perhaps eight to nine percent of doctoral oceanographers. Of course, this means that everyone on the cutting edge of marine chemistry research is in touch. But it also means we have more ideas for doing things than there are people or time to do them."

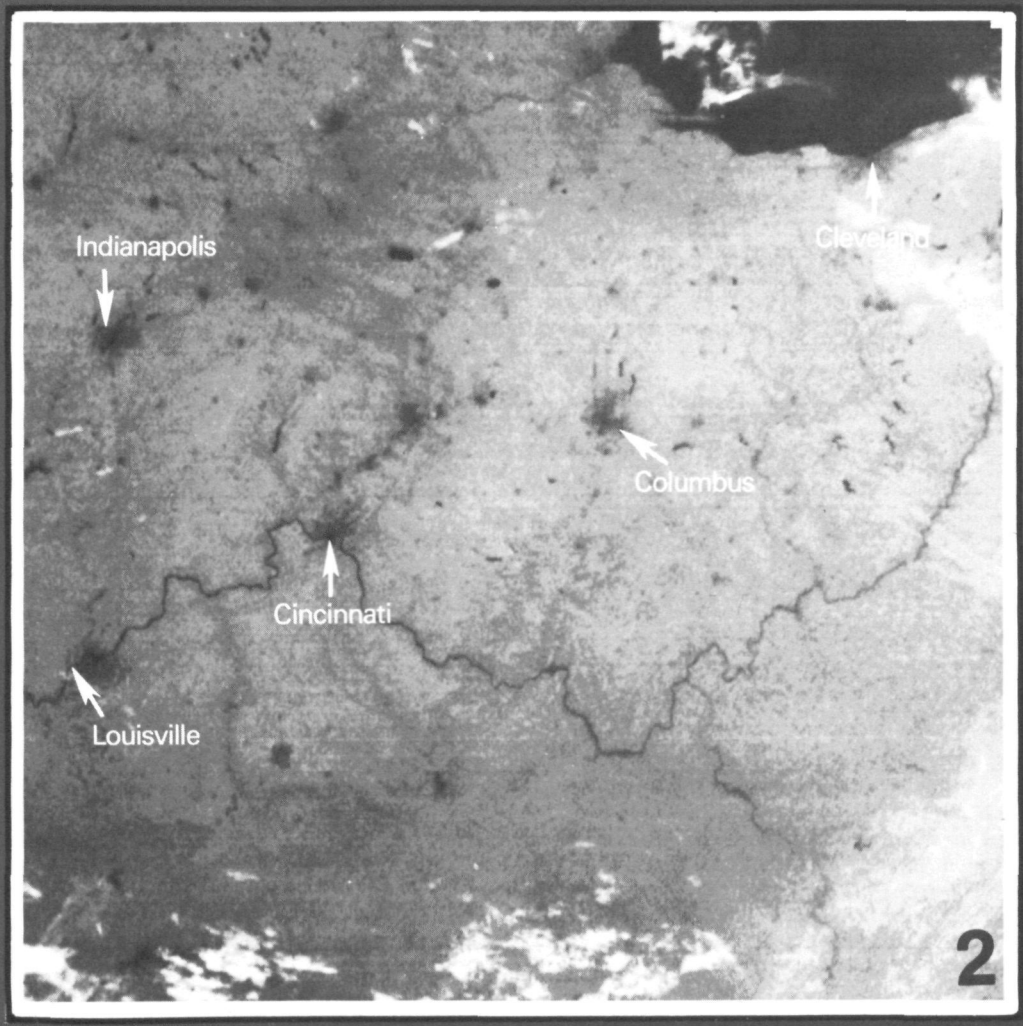
To Curl, the field is developing rather slowly, with fewer marine chemists than other types of oceanographers in any given oceanographic lab, a fact of life that tends to limit employment opportunities. "Graduating chemists can also find better salaries and positions in the chemical industry ashore, which tends to snap them up long before they get into oceanography," he said. "The fact is we may be less glamorous in the public view than marine biologists. We have no Cousteau." □



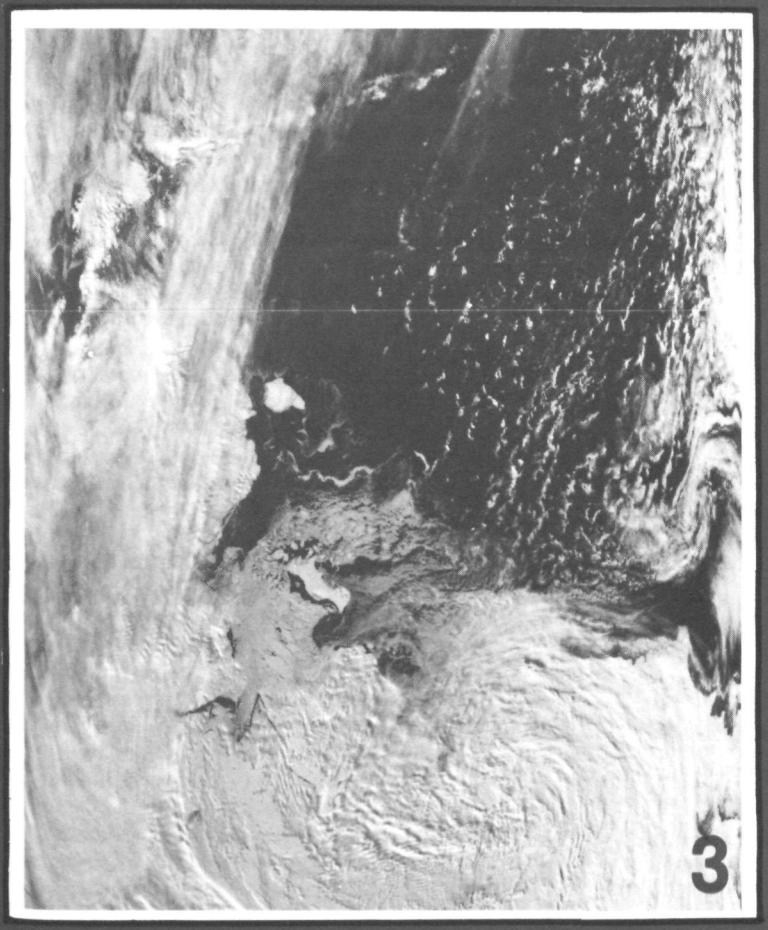
Crew members of the NOAA ship Miller Freeman (above) gingerly lower a pair of sediment traps into the chilly waters of lower Cook Inlet, while Seattle laboratory's Dr. Richard Feely (at lower right) looks on.

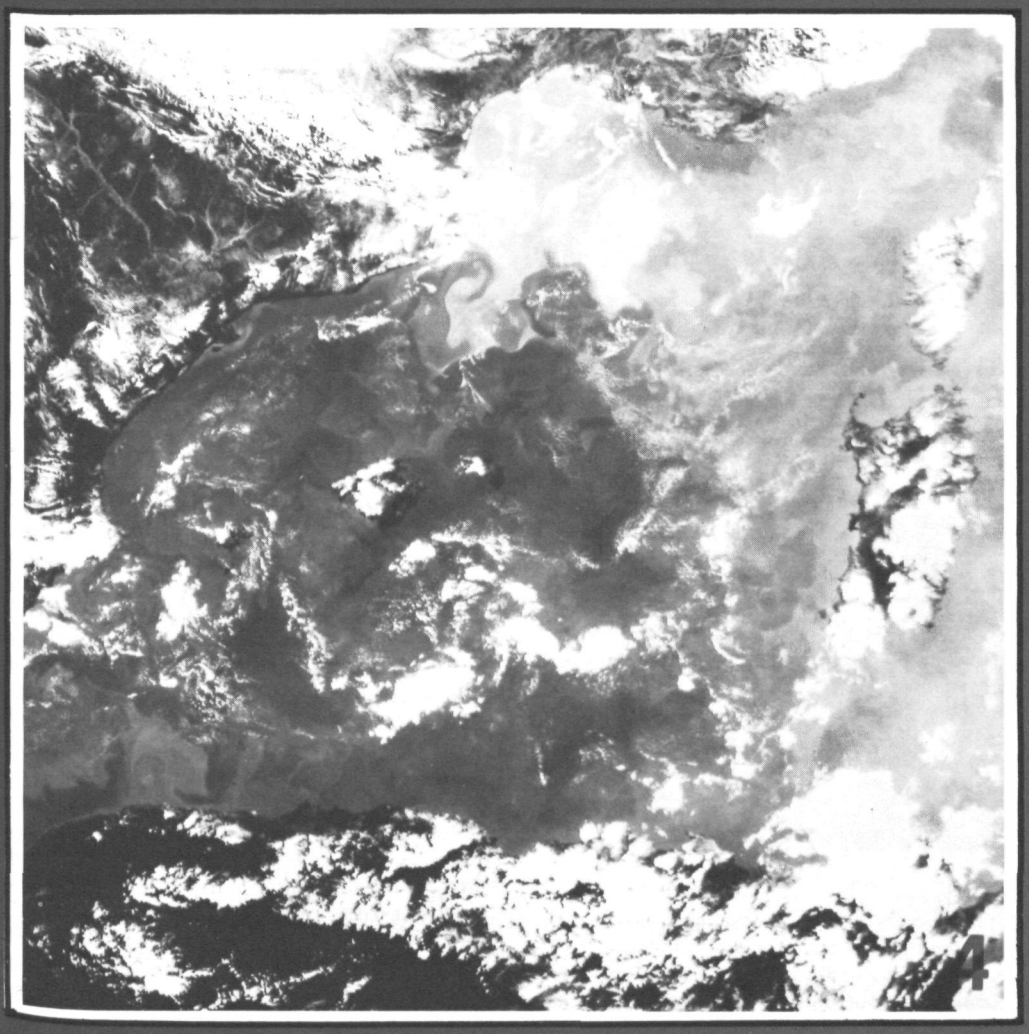
Pacific Marine Environmental Laboratory's Dr. Joel Cline (right) with gas harpoon developed by the laboratory to allow in-place sampling waters in sediments. The harpoon collects samples of filtered water for gas chromatrograph analysis on board ship.

THE VIEW FROM SPACE



Heat and cold are the subjects of this issue's selection of satellite imagery pictures: pictures from space showing ice where it usually isn't, water where normally there is ice, and the heat of our cities as well as of distant lands and waters. All these images are important to scientists, as they add a bit more data to the matrix of knowledge about the planet upon which we live.



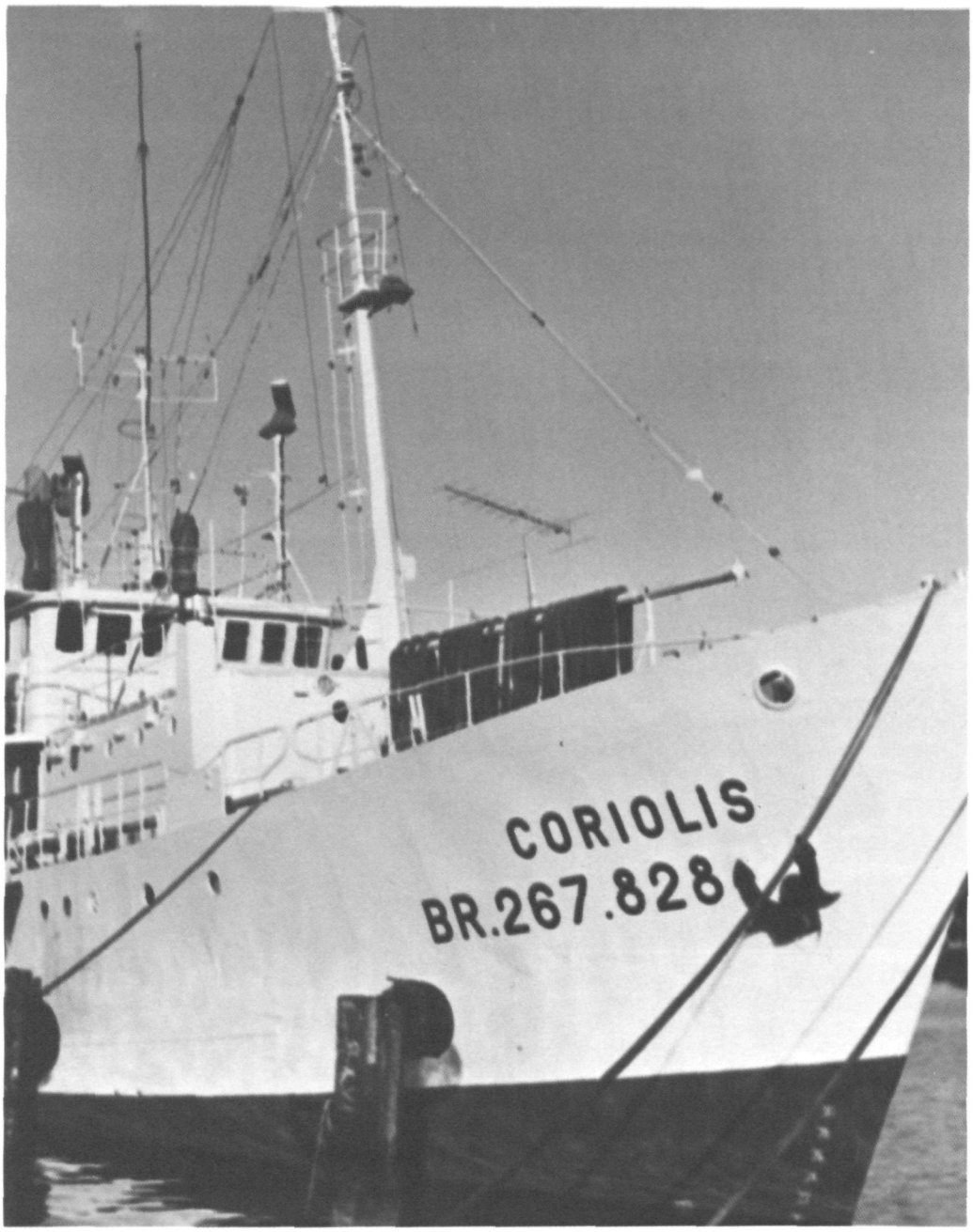


1 Ice cover over the Great Lakes was unusually heavy this past winter, as evidenced by this TIROS-N visual imagery of February 17. The ice cover over the entire area averaged greater than 90 percent. Lake Ontario was 80 percent covered. The previous maximum coverage of that lake was 51 percent in the winter of 1962-63.

2 Heat from mid-west cities shows their location in this NOAA-5 infrared image. Scientists with NOAA's National Environmental Satellite Service believe analysis of enhanced imagery of this sort will help city planners see metropolitan growth almost as it occurs.

3 While the Great Lakes had more ice than usual, the Bering Sea ice pack this year was breaking up earlier than normal, as this March 26 TIROS-N image shows. The ice edge seen here is nearly 200 miles north of its normal seasonal position.

4 Extremely clear variations in the water temperatures of the Western Mediterranean may be seen in this enhanced image from TIROS-N received and processed by the University of Dundee in England. The hot landmass of Algeria on November 1, 1978, is shown almost jet black while the cold clouds above are nearly pure white. Variations of grey in the waters of the Mediterranean show temperature differences.



NOAA Corps officers on French research ship

A Different World

The tropical cyclone had passed several hundred miles to the north of Coriolis, a French research ship on a marine geophysics and seismicity project in the South Pacific last November. But the effects of the big storm showed on the ship and its occupants. For more than a week the vessel rolled and pitched in mountainous seas—one moment deep in a trough, the next moment high on the crest of a great wave.

About the only level object on the Coriolis was a gravity meter, affixed to a gimbaled table in the laboratory and undisturbed by the ship's motion.

The operator of the gravity meter was Lt. Cdr. Richard S. Moody, NOAA Corps. Time and again the Coriolis set out to sea, worked a few days, and returned to port, as unremitting gale winds and high seas hampered the work and made data gathering along the Tonga Trench extraordinarily difficult.

The poundings at sea, fortunately, were only part of the expedition, and many days passed when the sailing was excellent and the data-gathering easy. Moody and his U.S. companions became a part of a different world, that of a French research vessel.

The project to which Moody had been assigned was the result of recommendations by a group of experts on marine geophysics and seismicity that met in Galveston, Tex., in late 1975, where a five-year investigation of the geodynamics of the Southwest Pacific was proposed. The participants included Alex Malahoff, chief scientist for NOAA's National Ocean Survey, C. L. Drake of Dartmouth College, L. W. Kroenke of the University of Hawaii, C. A. Burke and G. V. Lathan of the University of Texas, and Jacques Dubois of the University of Paris and the Office de la Recherche Scientifique et Technique Outre-Mer (ORSTOM).

"The project's basic objectives," said Malahoff, "are to study the crustal structure interactions between the Indian Ocean and Pacific Plates at the site of the New Hebrides Trench and the Fiji Plateau." Another important objective was to understand the source of the 70 meter geoidal high located near the center of the Fiji Plateau and its association with the structural trends of the plateau including the gravity effects of the Indian Ocean Plate that is retracting from beneath the New Hebrides Trench.

"We expect that this cooperative program," said Malahoff, "will not only increase our understanding of earth dynamics, but also provide an insight into the mechanism by which earth resources are generated." The region is one of the most seismically active on earth, and encompasses an area equal to that of more than two-thirds of the U.S.

The initial field programs were conducted during 1976 and 1977. Critical to the success of the Coriolis' project was the site selection from which the scientists would obtain data on refraction, coring, dredging and heat flow. Before the shipboard expedition could take place, sites of interest were selected through an airborne magnetics study of the Fiji Plateau aboard a fully instrumented flying laboratory, a P3 Orion, based at Patuxent, Md. This study was conducted jointly by NOAA and the Naval Research Laboratory in 1977, and was funded by the Office of Naval Research.

Flown at an elevation of 600 feet (180 meters) above sea level, the detailed survey provided a remarkable picture of the tectonic evolution of the Fiji Plateau from which new clues to the locations of spreading centers and the directions of structural trends were to be obtained.

The first step towards confirming the existence of the extension of the plateau would require shipboard gravity, seismic reflection and magnetic center data. It was now the moment to approach the National Geodetic Survey for assistance.

"The experiment," wrote Malahoff to NGS Director John O. Phillips, "will provide an excellent and unusual opportunity for a bright, geodetically oriented NOAA Corps officer to get involved in an internationally important experiment." Malahoff requested NGS cooperation through the assignment of two officers with the La Coste Romberg stable-based platform marine gravimeter aboard the Coriolis scheduled to begin the expedition to the South Pacific in May 1978.

In 1978, ORSTOM contributed ship time and marine geophysics; Cornell University provided and expanded existing island-based seismography stations and networks; and the University of Texas developed the marine refraction and earthquake ocean-bottom seismograph equipment that was to be operated by the scientists aboard the Coriolis during the second expedition in November.

By March, the NOS scientific team had been assembled. It included Malahoff, its principal investigator; and William Strange and William Carter, both NGS experts in gravity and geodesy. Two NOAA Corps officers—Lt. Cdr. Richard Moody and Lt. (jg) Warren Dewhurst—were to be responsible for data collection.

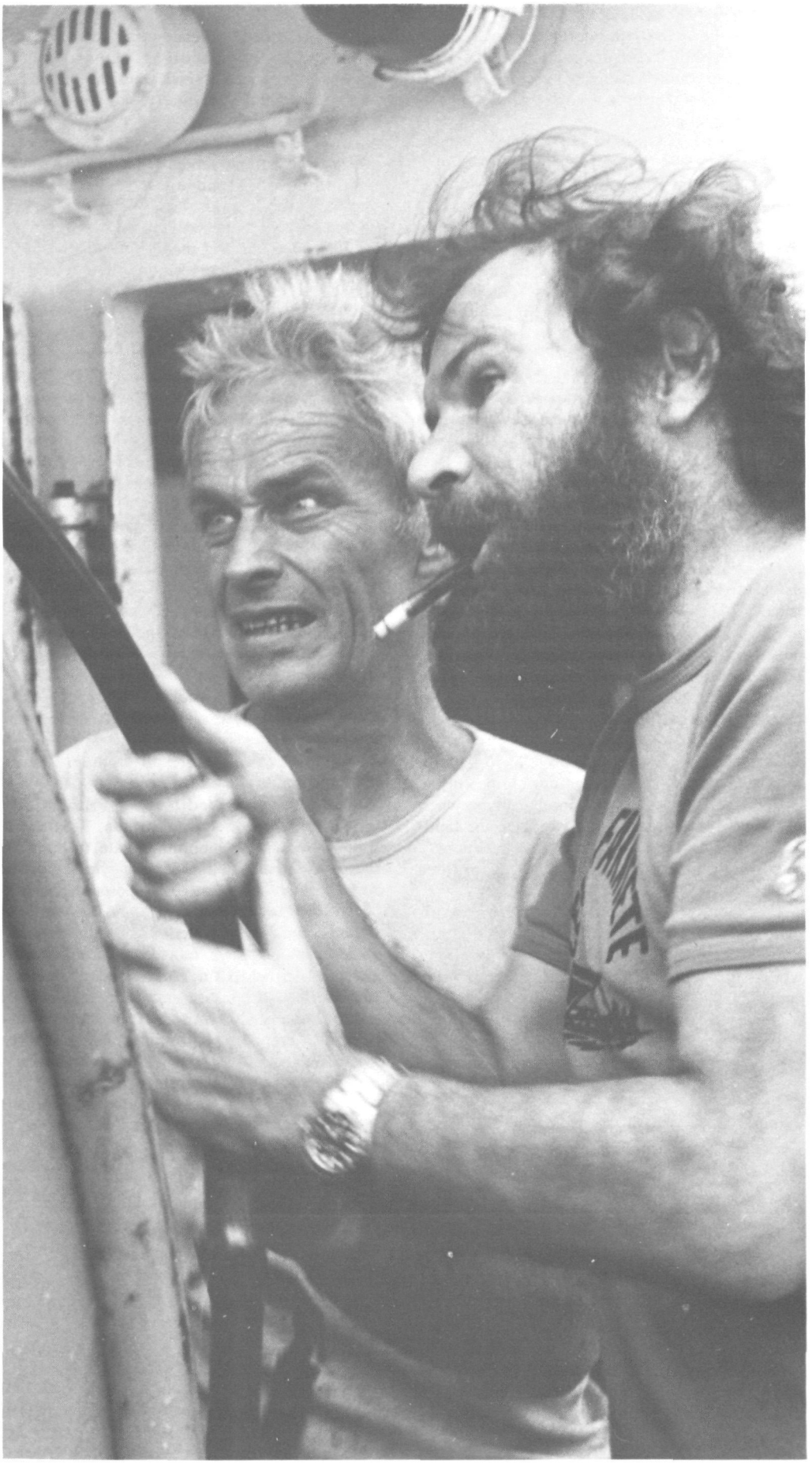
"I jumped at the chance to go on the expedition," said Dewhurst, "and Denise understood." Denise was his soon-to-be wife—they were married just two weeks before he departed for the South Pacific.

On special assignment to NGS for the May expedition aboard the Coriolis, Dewhurst had been working with the Coastal Mapping Division at NOAA's Atlantic Marine Center, Norfolk, Va. "My main interest is geophysics," said Dewhurst, who received a B.S. degree in Geophysical Engineering from the Colorado School of Mines in Golden, Colo. Prior to joining the NOAA Corps in 1975, he had worked in private industry with air-sea gravity meters and with geophysics in general.

Moody went into the NOAA Corps straight from graduate school at the University of Washington where his major study was biological oceanography. His first assignment was aboard the NOAA Ship Mt. Mitchell in 1968. He also has "worked hydro" off the Carolinas and Puerto Rico.

Moody came to Rockville, Md., as an aide to the NOAA Administrator during the transition from ESSA to NOAA. Subsequent assignments have included the Great Lakes, the GATE project, and then to Alaska on the Outer Continental Shelf Environmental Assessment Program.

One of the major objectives of the Coriolis mission during 1978 was to find evidence of a spreading expansion zone in the middle of the



The hauling and setting of the seismic cable often demanded a frantic effort by the crew of the Coriolis since the winch drum was makeshift, and required constant attention.

Fiji Plateau because, Moody said, "the area seems to be a focal point for the collision of several tectonic elements, including the Australian Plate, which are moving past each other and seem to be forming a vortex in the vicinity of the Fiji Islands.

"In addition, the Australian Plate is being subducted under the New Hebrides Trench, and because of the addition of mass, mantle material rises from below forming an island arc—the New Hebrides Islands."

"The purpose of the first expedition," said Moody, "was to take continuous gravity measurements between New Caledonia and Fiji. Basically, we were attempting to get East-West and North-South track lines across the relatively shallow North Fiji Basin which is also called the Fiji Plateau, to see the variations of gravity and magnetics across the middle of the Plateau, the southern New Hebrides Trench, and across the ridge just to the North of the Trench.

"We would deploy the ocean bottom seismographs and run perpendicular to the regular track line shooting off the air gun. The seismometer picked up the signal as the sound pulses traveled through the different layers of the bottom, so we got a form of seismic refraction."

Moody said that the second trip obtained data on bathymetry and marine gravity, and from the ocean bottom seismometers. "The first trip in May," he said, "consisted of magnetics, gravity, and bathymetry and seismic reflection."

Moody and Dewhurst shared a 36-square-foot stateroom. "We washed our clothes in the sink or the shower," said Moody. "And when the weather was reasonable, we took the laundry outside and hung it on a line somewhere." The longest time they were at sea was for three weeks.

If their living conditions were crowded, their working arrangements were hardly better. The laboratory was in the center of the ship where the gravity meter was located on a counter originally used for cleaning fish.

"We were very cramped most of the time," Moody said. "To move around the counter, we had to move sideways because the lab was stacked to the overhead with hardware, and there were no portholes." On scheduled watches, they maintained and annotated the machines taking bathymetry and seismic data, gravity and magnetics.

It was a different world for the two officers. There were animals aboard, and on the second trip, three dogs and a cat. "That's traditional," Moody said. "They sometimes have goats and pigs as pets."

Lunch was the big meal, and depending on the watch the officers stood, they would eat either at 11 or noon.

"There are at least two entrees for lunch," Moody said. "If there was fish or seafood there would be at least one bottle of white wine, and there was always red table wine. As we finished the bottles, they were thrown out the porthole, and more wine was brought in by the messman. It was supplied at each meal until we felt like stopping the flow." Aperitifs were served before the meal and digestives afterwards.

"Then back to the lab," said Moody. Dinner was at seven or eight o'clock, and beverage and junk food dispensers were not to be found aboard the ship.

"It was a very good diet," said Moody who lost a total of about 15 pounds on both expeditions. "They really stay away from anything that contains artificial flavoring or coloring."

The crew of the Coriolis was from the South Pacific islands. They spoke French, and only one, from New Hebrides, spoke any English. The ship's officers were all from France except one man who was from Newfoundland. "On the first expedition," said Moody, "Dewhurst was the spokesman. I knew no French so I had to communicate through the chief scientist. On the second trip, I learned some French, and that really helped a lot."

During the fall mission, the Coriolis made transits from New Caledonia to the Fiji area and beyond to the east across the Tonga Trench. In addition, the ship ran closely spaced lines of gravity and bathymetry across approximately 200 miles of the South New Hebrides Trench. "I brought back more than two miles of strip chart records of gravity," Moody said.

The Dynamics of the Southwest Pacific Program has moved into its third year of the proposed five-year project. "Its emphasis for the second year," said Malahoff, "was to continue the seismicity studies in the New Hebrides, start seismicity studies in the Tonga area, and make preliminary studies of the northern end of the Tonga subduction zone."

During the program's third year, the focus will be to concentrate on the natural seismicity and crustal structure in the central Tonga area. Depending on the availability of instruments, natural seismicity studies will also be conducted in the northern Tonga area and continued in the southern New Hebrides.

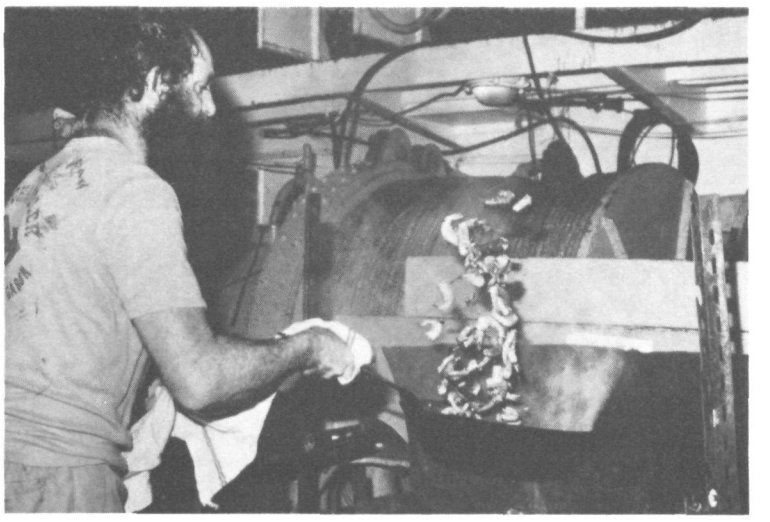
"The remaining two years," Malahoff said, "will concentrate on the major unresolved problems. It is difficult at this time to estimate what these might be. For example, additional detailed and specific work might be needed in the southern New Hebrides or northern Tonga zones. Broad arrays for deeper earthquake studies might be needed, or closer arrays for added details of shallow events. In addition, major volcanic activity or the aftershocks of a major quake might require short-term attention."

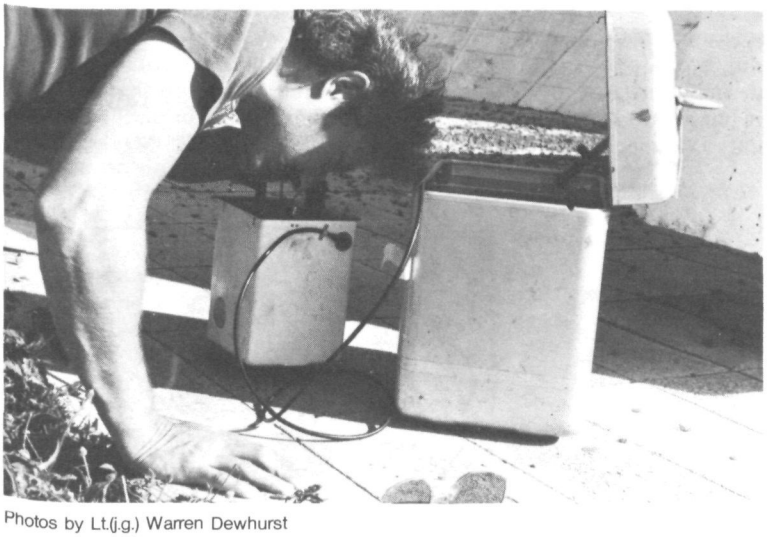
Malahoff said that it is apparent that in addition to the important, specific problems, a major focus of the program's concluding years would be to tie together the dynamics of the area bounded by the Tonga and New Hebrides subduction zones.

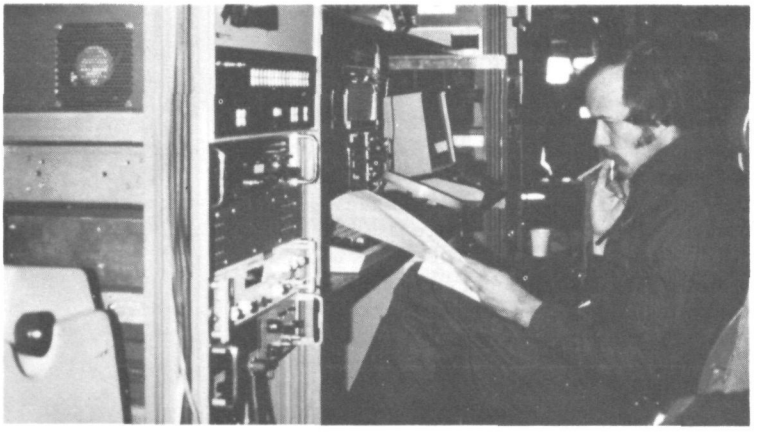
On the 8th of December 1978, Richard S. Moody left the Coriolis after 57 days at sea. He had completed 7600 nautical miles of bathymetry and gravity and 1100 nautical miles of seismic reflection, 10 ocean bottom seismographs had been deployed and recovered with seismic refraction profiles.

Moody acknowledged that the scientists and administrators at the geophysical institute at ORSTOM were very helpful in getting the job done. "It was a pleasure," he concluded, "to sail with the officers and crew of the Coriolis—and I consider all of them my friends, including the three dogs and the cat." □

Coming into a new port was always a time for excitement and anticipation.





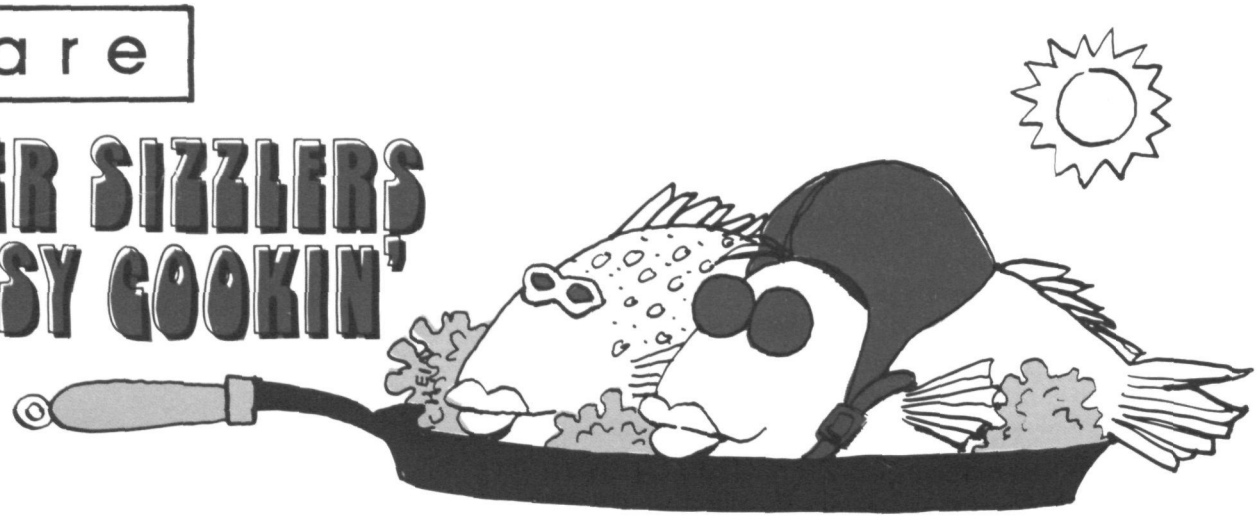


Photos by Lt.(j.g.) Warren Dewhurst

Francois Misseague, a French technician (upper left) and Jacques Daniel, the chief scientist during the first cruise, supervise a Malaynesian crew member in the storage of the seismic cable. The dogs aboard the ship often assisted in this operation. Lt. Cdr. Richard Moody, of the NOAA Corps, operates the LaCoste and Romberge Land Meter (lower left) to determine a base tie for comparison with the readings of the Air-Sea Gravity Meter. Not all was work aboard the Coriolis. The ship's cook (upper right) flips a mess of fresh shrimp for a French cookout on the fantail. A year before the Coriolis steamed to the South Pacific, an airborne magnetics study (lower right) of the Fiji Plateau aboard a P3 Orion from Patuxent, Md., was conducted by NOAA and the Naval Research Laboratory.

SeaFare

SUMMER SIZZLERS FOR EASY COOKIN'



Summertime . . . and the cooking can be easy, especially if the grill is ready and the menu includes fish.

The following recipes will make any summer meal a pleasant experience. Wood chips, soaked in water for at least an hour before using and added a few at a time to the fire, give a pleasant smoky flavor to fish. Fish should be cooked until they flake easily when tested with a fork.

Grilled Fillets with Barbecue Sauce

2 pounds cod, haddock, pollock, grouper, or other thick fish fillets, fresh or frozen
1 cup catsup
1/3 cup lemon juice
¼ cup cooking oil
2 teaspoons Worcestershire sauce
1 clove garlic, minced
½ cup chopped onion
¼ cup water
1 teaspoon sugar
¼ teaspoon liquid hot pepper sauce
¼ teaspoon liquid smoke, optional
1 small bay leaf

Thaw fillets if frozen; cut into serving-size portions. Place portions in single layer in shallow baking dish. Combine ½ cup catsup, lemon juice, oil, Worcestershire sauce, and garlic. Pour sauce over fish. Cover and refrigerate about 1 hour, turning fish once. Remove fish, reserving sauce; drain. Use half of sauce for brushing fish while grilling. Combine remaining half of sauce with remaining catsup, onion, water, sugar, liquid hot pepper sauce, and liquid smoke, if used, and bay leaf. Simmer about 20 minutes to thicken and blend flavors. Place fish in well-greased, hinged wire grills. Cook about 5 inches from moderately hot coals for 8 minutes. Baste with sauce. Turn and cook for 7 to 8 minutes longer or until fish flakes easily when tested with a fork. Brush fish with sauce as needed during cooking. To serve, spoon barbecue sauce over fish. Makes 6 servings.

Broiled Salmon Steaks with Currant-Lemon Barbecue Sauce

6 salmon or halibut steaks, (¾ to 1-inch thick) or other fish steaks, fresh or frozen
½ cup lemon juice
¼ cup currant jelly
¼ cup corn syrup
¼ cup margarine or butter
3 tablespoons catsup
1 tablespoon prepared mustard
1 teaspoon cornstarch
1 teaspoon salt

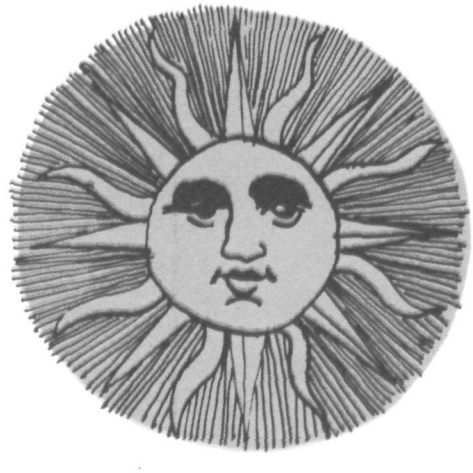
Thaw steaks if frozen. Place fish in a single layer in a shallow baking dish. Brush steaks on both sides with lemon juice, cover and refrigerate for 2 hours before broiling. Just before broiling steaks prepare sauce. Combine remaining lemon juice, jelly, syrup, margarine or butter, catsup, mustard, and cornstarch in saucepan; stir until free of lumps. Cook until thickened, stirring constantly. Simmer 1 to 2 minutes.

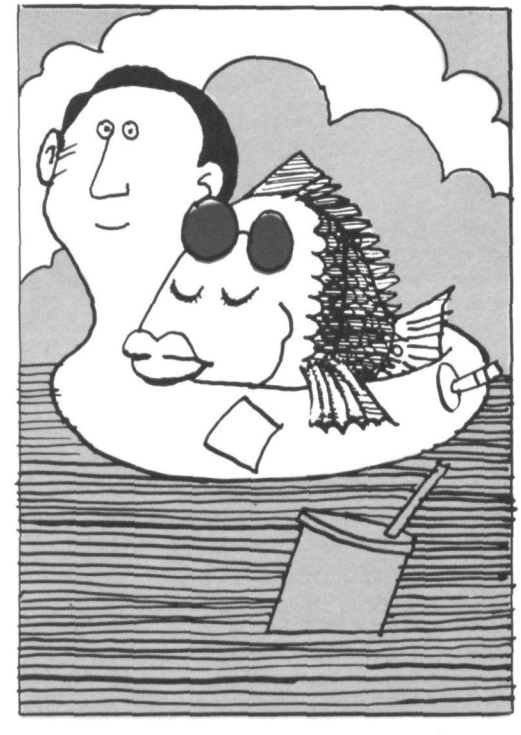
To Cook Over Open Fire

Drain steaks, sprinkle both sides with salt. Place fish in well-greased, hinged wire grills. Brush fish with sauce. Cook about 4 to 6 inches from moderately hot coals for 5 to 8 minutes. Baste with sauce. Turn and cook for 7 to 10 minutes longer or until fish flakes easily when tested with a fork. Serve with remaining sauce. Makes 6 servings.

To Broil in Oven Broiler

Drain steaks, sprinkle both sides with salt. Place fish in a single layer on a well-greased broiler pan. Brush fish with sauce. Broil about 3 to 4 inches from source of heat 4 to 6 minutes. Turn carefully and brush with sauce. Broil 4 to 6 minutes longer or until fish flakes easily when tested with a fork. Makes 6 servings.





Striped Bass Italian Spaghetti Dinner

2 pounds striped bass, snapper, grouper, or other thick fillets, fresh or frozen
¼ cup cooking oil
1 tablespoon lemon juice
½ teaspoon salt
½ teaspoon oregano
1 clove garlic, sliced
1 jar (32 ounces) commercial spaghetti sauce
8 to 12 ounces spaghetti, uncooked
½ cup shredded or grated Parmesan cheese

Thaw fillets if frozen; cut into serving-size portions. Place fish in single layer in shallow baking dish. Combine oil, lemon juice, salt, oregano, and garlic. Pour sauce over fish. Cover and refrigerate about 1 hour, turning fish once. Remove fish, reserving sauce for basting. Place fish in well-greased, hinged wire-grills. Cook about 5 inches from moderately hot coals for 8 minutes. Baste with sauce. Turn and cook for 7 to 8 minutes longer or until fish flakes easiy when tested with a fork. While fish is cooking, heat spaghetti sauce and cook spaghetti as directed on package. Serve spaghetti on individual plates, top with fish, and spoon sauce over fish and spaghetti. Sprinkle with cheese. Makes 6 servings.

Grilled Panfish with Fresh Vegetable Sauce

6 (6 to 8 ounce) pan-dressed yellow perch, catfish, croaker, black sea bass, or other small pan-dressed fish, fresh or frozen
2 tablespoons margarine, melted
1 teaspoon salt
3 strips bacon, diced
6 large green onions, sliced (about 1 cup)
½ cup chopped green pepper
1 ½ cups chopped fresh tomato
6 to 8 pitted ripe olives, sliced
½ teaspoon garlic salt
Dash pepper

Thaw fish if frozen. Clean, wash, and dry fish. Cover head and tail with foil. Brush fish inside and out with melted margarine. Sprinkle with ½ teaspoon salt. Place fish in well-greased, hinged wire grills. Cook about 5 inches from moderately hot coals for 6 to 8 minutes. Baste with melted margarine. Turn and cook 7 to 10 minutes longer or until fish flakes easily when tested with a fork. Brush fish with melted margarine as needed. While fish is cooking, fry bacon until crisp; remove bacon bits and drain on paper towels. Add onion and green pepper to drippings; cook until onion is tender, but not brown, 3 to 4 minutes. Add tomatoes, ripe olives, remaining ½ teaspoon salt, garlic salt, and pepper; cook until tomatoes are heated, but still hold their shape. Sprinkle with bacon bits. Serve immediately over cooked fish. Makes 6 servings.

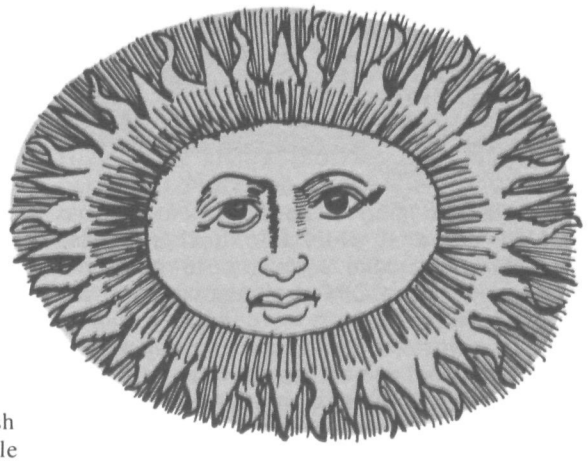
Note: For a Mexican-style sauce add 1 to 3 tablespoons chopped jalapeno peppers with tomatoes before heating.

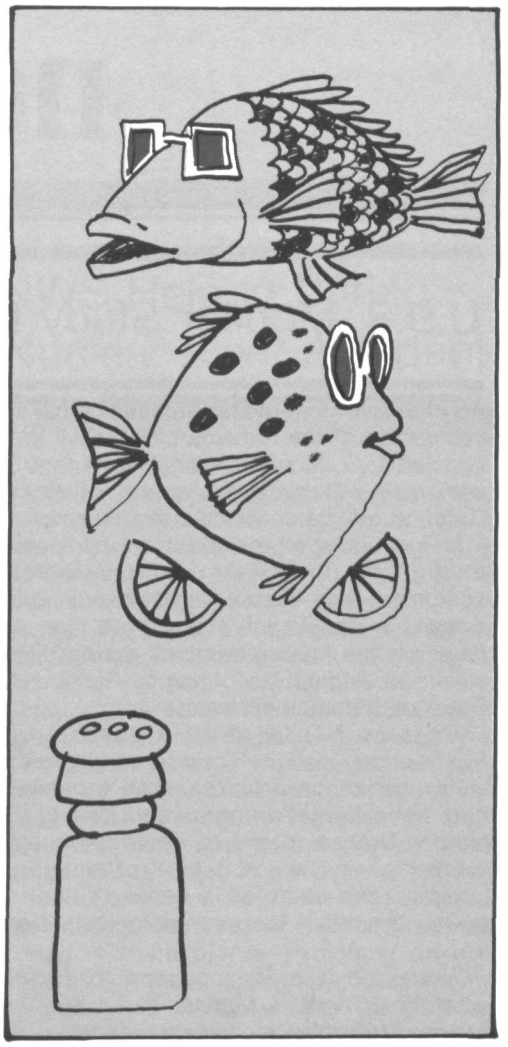
Shrimp Kabobs Cooked on Hibachi or Small Grill

Assemble kabobs as directed. Arrange kabobs on well-greased hibachi. Brush with sauce; sprinkle with mint, if desired. Cook about 4 inches from moderate heat about 5 minutes. Brush with sauce, sprinkle with mint if desired. Turn and cook 4 to 5 minutes longer or until shrimp is cooked, pink and lightly browned. Remove foil from tails. Serve any remaning sauce with kabobs.

Shrimp Kabobs Broiled in Oven-Broiler

Assemble kabobs as directed. Place kabobs on well-greased broiler pan, brush with sauce; sprinkle with mint if desired. Broil about 4 inches from source of heat for 5 minutes. Turn, brush with sauce and sprinkle with mint, if desired. Broil 4 to 5 minutes longer or until shrimp is cooked, turns pink and is lightly browned. Serve any remaining sauce with kabobs.





Glazed Shrimp Kabobs with Fruity Glaze

2 pounds raw large shrimp (14 to 15 per pound), fresh or frozen
18 lime or lemon wedges
½ cup apricot preserves
½ cup orange juice
½ cup lemon juice
¼ cup honey
1 tablespoon cornstarch
2 to 3 drops hot pepper sauce
1 teaspoon chopped fresh or dried mint, optional
Fruit Kabobs (banana slices, orange wedges, fresh pineapple chunks, and melon chunks), optional

Thaw shrimp if frozen. Peel raw shrimp leaving tails on. Remove sand veins and wash. Thread the following on metal or bamboo skewers: a lime or lemon wedge, 3 shrimp, a lime or lemon wedge, 3 more shrimp and another citrus wedge. Cover tails of shrimp with aluminum foil. Place kabobs on a tray, cover and refrigerate until ready to cook. Prepare sauce. Combine preserves, orange and lemon juice, honey, cornstarch, and hot pepper sauce; stir until no cornstarch lumps remain. Cook until sauce thickens slightly, stirring constantly; simmer 3 to 4 minutes. Broil kabobs on hibachi or in the oven. Serve with favorite fresh fruit kabobs, if desired. Makes 5 to 6 servings.

U.S.S. Monitor Study Planned for August

An intensive underwater archaeological investigation of the remains of the Civil War ironclad U.S. Monitor, lying in 210 feet of water 16 miles off the coast of North Carolina, will be conducted this summer.

Using some of the most sophisticated diving and underwater archaeological equipment ever used on any wreck in U.S. waters, scientists will make more than 30 dives on the historic remains during three weeks in August, according to Richard A. Frank, NOAA Administrator.

He said NOAA and Harbor Branch Foundation, Inc., a Florida-based underwater oceanographic research organization, have signed an agreement calling for Harbor Branch divers to photograph and video tape the wreck, test it for structural integrity, and establish a series of control points around it for archaeological reference.

"Although it is far too soon to decide whether or not the Monitor can safely be raised, the expedition will provide valuable additional information to help us ultimately make this decision," Robert W. Knecht, head of NOAA's Office of Coastal Zone Management, said.

OCZM acts as manager and trustee of the Monitor site, which was declared the Nation's first national Marine Sanctuary in 1975.

Since its discovery in 1973, the Monitor has been the object of scientific and public fascination that may turn out to rival its Civil War popularity.

To date, the most useful information regarding the Monitor's condition has come from pictures taken in August 1977 during an earlier NOAA-Harbor Branch collaboration. These showed the wreck lying upside down, with its famous "cheesebox" armored turret detached and half buried in the Atlantic sand.

In that series of dives onto the remains, a signal lantern believed to have been carried on the Monitor's deck the night the ship sank while under tow in 1862 was recovered. Also brought to the surface was a 65-pound piece of hull plating.

During this summer's expedition, attempts will be made to recover any additional artifacts from the forward part of the vessel.

Specially designed containers are being made by the North Carolina Department of Cultural Resources to stabilize and preserve any artifacts recovered until they can be transported to a conservation laboratory.

Roger Cook, Operations Director for Harbor Branch, said the foundation's submersible, the Johnson Sea-Link, and several support vessels will be used in the expedition. Additionally, the North Carolina Department of Cultural Resources is designing special pieces of equipment for the study.

"We don't know at this stage exactly what we're going to find when we get down there," Cook said. "But, we expect to get a better idea of just what condition the ship is in, and we plan to bring up a number of important samples that will help us determine its structural integrity."

NOAA Employee Uses CPR to Save a Life

Betty Leonard

While attending a Mardi Gras parade in New Orleans, Betty Leonard, a NOAA/ADMIN employee, revived a 16-month old child with the CPR training she had received recently.

The parent's cry for help was answered by Leonard, and by the time the police got the ambulance and medics through the throngs watching the parade, the child was stabilized.

"I never thought I would use it," said Leonard of the CPR training she took at the Census Building in Suitland, Md., so that if her husband had a heart attack she might be able to save him. "I now think about my fellow employees, strangers in the shopping center. And, most of all, I wonder who might be around to help me in case I needed CPR."

Monk Seal Is Added To Endangered List

The Caribbean monk seal, indiscriminately killed for hides and oil since early Spanish exploration of the western hemisphere, has been listed as an endangered species by the National Marine Fisheries Service.

NOAA scientists fear the animal may already be extinct since surveys and studies have failed to locate any of the mammals in its former habitat in the Gulf of Mexico and Caribbean Sea.

Under the Endangered Species Act of 1973, an endangered species in one that is in danger of becoming extinct throughout all or a significant part of its range and is protected from any contact by man.

Karl W. Kenyon, a noted marine mammalogist, conducted an extensive aerial survey of the Caribbean monk seal's former habitat in the Gulf of Mexico and Caribbean Sea in 1973 and failed to locate any of the seals. This survey and a study by NMFS scientist Dale W. Rice provided the basis for the assumption that the species is extinct.

Fire-retardant Chemicals May Come from the Sea

Use of chemical compounds from aquatic plants to help make children's clothing safer from fire is being studied by Sea Grant researchers at the University of Washington, in projects being undertaken there under a grant from NOAA.

Scientists are analyzing the properties of an abundant Pacific Northwest alga which has enzymes that cause chemicals to bond fabrics, making them fire resistant. They believe that the plant enzymes could be an economical and effective substitute for fire-retardant chemicals that were removed from the market because of their possible contribution to the incidence of cancer.

The University of Washington has received NOAA funding since 1969. One of the largest Sea Grant Programs in the Nation, it was among the first four institutions in the United States to receive Sea Grant College status for demonstrating an integrated program of applied research, education, and advisory services.

Administrator Signs Accords with China

Secretary of Commerce Juanita M. Kreps (center) leads members of the U.S. and Chinese delegations in applauding the signing of an accord on atmospheric science and technology by NOAA

Administrator Richard A. Frank (l.) and Xue Weimin (r.), First Deputy Director of the Central Meteological Bureau of the People's Republic of China.

Returning from a May visit to the People's Republic of China, NOAA Administrator Richard A. Frank brought with him three implementing accords signed with China's Central Meteorological Bureau, State Oceanography Bureau, and Aquatic Products Bureau. Frank accompanied Secretary of Commerce Juanita M. Kreps on the 11-day visit.

In a ceremony with representatives of the Chinese government, Frank signed a landmark agreement establishing collaborative efforts in atmospheric science and technology.

For the first time, weather research and forecasting efforts of the two nations will be linked, for their mutual benefit and the benefit of meteorological services throughout the world.

Computer modeling and forecasting of weather, better use of satellite data for weather information, and increased knowledge of severe storm research and broad-scale weather patterns will be enhanced by work under the agreement.

An historic agreement which will bring close collaboration between oceanographers and fishery scientists of the U.S. and China for the first time was also signed.

Five specific areas of activity will begin under the agreement and an annex: Marine Data Exchange, Marine Sedimentation Processes Aquaculture, Tuna Fishery Activities, Marine Environmental Services.

The agreement also provides for activities that have been agreed upon in principle, but that require further arrangements. These include Chinese study of moored data buoy systems and ocean instrumentation systems, marine environmental monitoring and prediction exchanges, a mutual program of numerical computer modeling of marine systems, air-sea interaction and physical oceanography visits, and long-term cooperative studies on the biology of fish, emphasizing techniques valuable to aquacluture.

Another agreement pledged cooperation leading to the establishment of a new weather station over China to help provide improved weather forecasting and better service to commercial aviation in both countries—and throughout the world.

The new weather station will obtain meteorological information at high elevations in the stratosphere over a critical part of the Asian land mass that heretofore was closed to American scientists. Weather patterns generated over Asia often continue eastward, affecting the weather of the Pacific Ocean and the northwest United States.

NWS Helped During Nuclear Plant Accident

The National Weather Service provided a variety of observational and forecast information in support of safety precautions taken during the Three Mile Island nuclear power plant accident beginning in late March.

On March 30, when the dangerous situation at the power plant became apparent, the National Meteorological Center began providing a special five-day forecast twice a day for the area which was made available to the Nuclear Regulatory Agency and the Federal Disaster Assistance Administration as well as State and local agencies. Day-by-day forecasting responsibility, with particular attention to the crucial wind speed and direction in the event of the release of large amounts of radiation, was assigned to the Weather Service Forecast Office in Philadelphia. Providing on-site support for these operations were members of an Air Force weather team at the Harrisburg airport and the National Weather Service's permanent staff at Harrisburg which was strengthened by additional personnel from the NWS Pittsburgh office.

The hydrology staff of the Harrisburg, Pa., River Forecast Center monitored flow for the Susquehanna River district which might have been affected by hazardous nuclear products.

NOAA's Environmental Research Laboratories also assisted during the emergency by providing a meteorologist from the Air Resources Labs' Idaho Falls Field Research Office to assist officials at Harrisburg with trajectory forecasts.

NOAA Awards Largest Minority Contract

A $787,650 contract to microfilm climatological records for the National Climatic Center in Asheville, N.C., has been awarded to a Washington, D.C. firm, Automated Datatron, Inc., and is the largest 8(a) program award ever made by NOAA.

The National Climatic Center is the collection point and custodian of all U.S. weather records, ranging from the contents of 18th century journals of George Washington and Thomas Jefferson to data currently collected by Federal agencies, foreign countries, and state and local agencies.

Owen Heads Oceanic & Atmospheric Services

Dr. Thomas B. Owen, former Chief of Naval Research and more recently an Assistant Provost at The American University, has been appointed NOAA's Assistant Administrator for Oceanic and Atmospheric Services.

A career Naval officer, retiring in May 1970 with the rank of Rear Admiral, Owen joined the National Science Foundation as Assistant Director. In 1974 he became Associate Dean for Graduate Affairs and Research in the College of Arts and Sciences at The American University, becoming Assistant Provost for Academic Support in 1976.

With NOAA, Owen will have overall responsibility for the National Weather Service, the National Environmental Satellite Service, the Environmental Data and Information Service, and the National Ocean Survey.

Owen received his BS (cum laude) degree in chemical engineering from the University of Washington, and graduate training in electronics at the U.S. Naval Postgraduate School.

He received his Ph.D. in chemistry through the Navy Advance Science program at Cornell University, and has also attended the Industrial College of Armed Forces and the Harvard University Graduate School of Business Administration.

23 Employees Receive Bronze Medals

Twenty-three NOAA employees received Bronze Medals from the Department of Commerce during the last six months of 1978. The Medal is awarded for extremely competent performance of official duties in the Department over a long period of time.

July: Wallace H. Blackwell, Jr., ADMIN: Donald R. Engle, NOS; Evelyn S. Liddel, EDIS; Irma Lee Westrell, ADMIN; Jack White, OCZM.

August: Mercedes N. Bakon, NWS; Walter Gilbert, NWS; John V. Graff, NWS; Joseph Judson, ADMIN; William E. Kennedy, NWS; Harold E. Lowman, NWS.

October: Louis Billones, NWS; Corinne G. Cook, NWS; Robert C. Embleton, NWS; Donald L. Olson, NWS; Walter W. Parker, NWS; Leo J. Sansregret, Jr., NWS; Arthur Valdemar, NWS.

November: Richard G. Anderson, NWS; Bonita Dobbins, NWS; Charlotte S. Jones NWS: Robert M. Stuart, NWS.

December: Jim H. Branson, NMFS.

New Federal Policy Aids Commercial Fishing

Proposed legislation reflecting a new Federal policy on developing commercial fishing resources was announced in May by NOAA Administrator Richard A. Frank, as the agency released $5,743,000 in Saltonstall-Kennedy funds under current legislation to support regional development of U.S. commercial fisheries.

Speaking at the opening session of a two-day national conference on fisheries development in Springfield, Va., Frank said the legislation will ensure adequate funding of efforts directed towards development of the industry, and better utilization of U.S. fishery resources, especially those not traditionally harvested by U.S. fishermen.

The new legislation would replace the Saltonstall-Kennedy Act—which earmarks part of the import duties on fish products for general assistance to the U.S. fishing industry—with a new law directed specifically toward development of the industry and utilization of U.S. fishery resources. The Administration would support appropriations under the new law which would increase funding over current levels. The law would expire at the end of FY 1984.

Noting that present Federal policy aims to foster the development of all sectors of the U.S. fishing industry—including fishermen in the 300-mile zone and the Great Lakes, U.S. flag distant-water fleets, and U.S. processors and distributors—Frank said achievement of these benefits will require an active and innovative partnership among the industry, state and local governments, and the Federal government.

"Commitments of time and resources will be required from all of the partners," he said. "And . . . the major work of implementing a National development policy must be done on a regional basis."

The program, he said, will enable the fishing industry and state and local governments to better utilize the many existing Federal programs for industry assistance and economic development.

Shipwrecks, Coral Reefs Found Off Key Largo

An extensive deepwater coral reef system and what may be as many as six shipwrecks, some perhaps dating back to Spanish exploration in the mid-seventeenth century, have been discovered by NOAA scientists in waters off Key Largo, Fla.

A team of NOAA marine scientists is investigating more than 50 square miles of the Key Largo Marine Sanctuary aboard the NOAA research vessel Peirce, commanded by Lt. Cdr. Floyd Childress. NOAA is responsible for managing the sanctuary, one of two in the country, as part of its charge to protect environmentally sensitive coastal waters.

Although a number of sunken ships already have been located in the 100-square-mile marine sanctuary and the area was known to contain uncharted coral reefs, the extent of the reef system and the number of newly-found wrecks came as a surprise to the scientists.

"Preliminary studies of a side scan sonar record indicate an undiscovered reef system about 14 miles long that may be almost as large as shallow water reefs that already have been identified," according to Childress.

The sonar record, which shows an almost photographic picture of the ocean bottom, also clearly indicates at least four, and possibly six, shipwrecks lying in 120 to 300 feet of water.

"One of the wrecks is about 190 feet long. Its size and shape suggest it is probably a freighter sunk within the past 30 years," Childress said. However, at least one other wreck shows up on the sonar record as the badly deteriorated skeleton of a wooden ship about 80 feet long.

Although Childress emphasized that without further investigation the identity of the wooden vessel, as well as the other wrecks, remains a mystery, he said that on at least two occasions in the 1600's, large flotillas of Spanish ships were lost in storms near the Key Largo sanctuary. Few of these vessels have ever been found.

Mark Is New Director Of NOAA Public Affairs

Albert Mark, active in public communications work for 23 years—seven of them as president of his own consulting firm—and a former Director of Communications for the City of Boston, has been named Director of Public Affairs for NOAA.

Most recently with the Agency for International Development in Washington, Mark was Coordinator of Communications for Hubert Humphrey's 1968 presidential campaign, and later became Assistant Administrator for Congressional Relations and Public Information for the U.S. Small Business Administration. He left that post in 1969 to work with Mr. Humphrey on co-founding the International Study Project for which he served as vice president.

In the mid-60's Mark worked for four years at the Democratic National Committee where he was Director of Public Affairs, Research, and Information.

He began his career as a researcher and United Press wire service stringer and correspondent in Europe, and then returned to his native New York City to enter public relations.

Mark received his undergraduate degree in sociology from the University of Wisconsin, and holds a Master's in International Affairs from Columbia University. He also attended the University of Paris (Sorbonne) as a graduate doctoral research fellow.

N.C. State Gets Help With Ag Weather Office

NOAA will help establish an agricultural weather office at North Carolina State University at Raleigh, serving agricultural interests statewide.

The office, providing agricultural weather services until now not available to North Carolina farmers, will be staffed by an agricultural specialist, whose salary expense will be shared by the State and the Department of Agriculture's Extension Service, and by a meteorologist, whose salary will be shared by the State and NOAA's National Weather Service.

Teletype writer circuits will connect the new office, expected to be in full operation by mid-summer, with NWS forecasters at Raleigh-Durham Airport who will supply the latest observations and forecast for North Carolina and other parts of the Nation. Radar reports, satellite data, and computer-produced forecast guidance also will be available.

The N.C. State staff will interpret this information for agricultural purposes and issue advices tailored to statewide farming operations, while weather forecasts will continue to be provided by NWS.

NOAA Awarded Cup for CFC Contributions

NOAA was awarded the Secretary's Cup for its outstanding contribution to the Combined Federal Campaign in the Commerce Department. Administrator Richard A. Frank accepts the cup from Assistant Secretary for Administration Elsa Porter. They are flanked by Dick Foster and Michael Binder who coordinated NOAA's effort.

Male Names Added to Atlantic Hurricane List

For the first time ever, this year hurricanes in the Atlantic, Caribbean, and Gulf of Mexico, will bear male as well as female names. And the first male name will be Bob.

Last year male and female names were used in the eastern Pacific Ocean. But because international agreement was necessary to add men's names to the Atlantic hurricane listing, it took an extra year to accomplish.

While this year's list starts with a female name, next year's will start with a male's. Five lists have been prepared by international agreement for use through the 1983 Atlantic hurricane season. In 1984, the 1979 names will again be used.

This year's list for Atlantic and Gulf Coast storms is: Ana, Bob, Claudette, David, Elena, Frederic, Gloria, Henri, Isabel, Juan, Kate, Larry, Mindy, Nicolas, Odette, Peter, Rose, Sam, Teresa, Victor, and Wanda. The letters Q, U, X, Y, and Z are not used because of the scarcity of names begining with those letters.

The name list has an international flavor because hurricanes are tracked by the public and the weather services of countries other than the United States. Names are selected from library sources and agreed upon during international meetings of the World Meteorological Organization by those nations involved.

NOAA's National Hurricane Center keeps constant watch on oceanic storm-breeding areas for tropical disturbances which may herald the formation of a hurricane. If a disturbance intensifies into a tropical storm, the Center gives it a name from the current list. Experience has shown that the use of short, distinctive given names is quicker and less subject to error, in written and spoken communications than more cumbersome latitude-longitude identification methods.

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