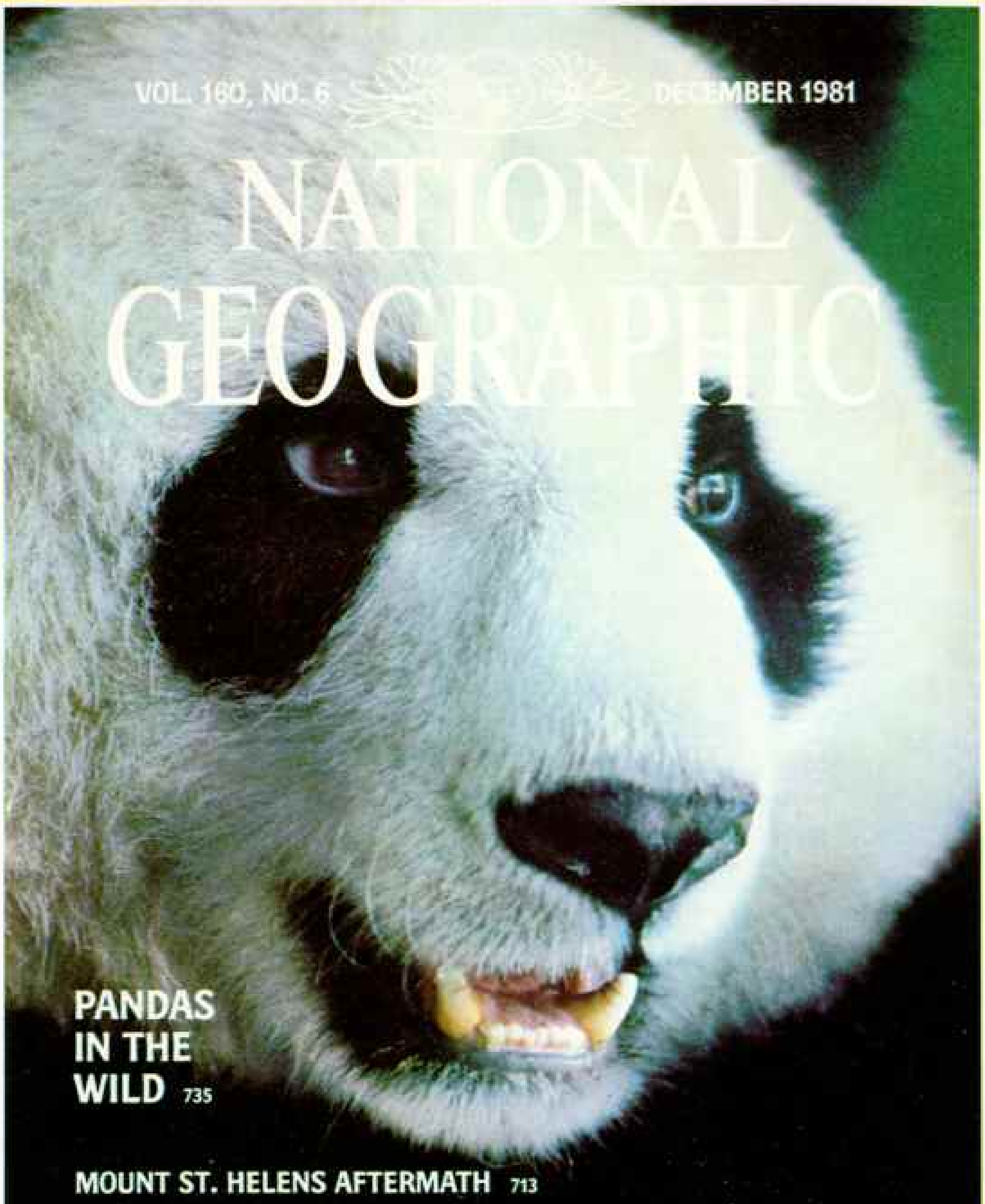
DOUBLE MAP SUPPLEMENT: THE WORLD AND WORLD OCEAN FLOOR

VOL. 160, NO. 6 DECEMBER 1981

NATIONAL GEOGRAPHIC



PANDAS IN THE WILD 735

MOUNT ST. HELENS AFTERMATH 713

ORANGE, A MOST CALIFORNIA COUNTY 750

THE OCEAN
A PERSPECTIVE: JACQUES-YVES COUSTEAU 780
AN ERA OF DISCOVERY 792
BLUE-WATER LIFE BY NIGHT 834

PRESIDENT'S REPORT TO MEMBERS 848

OFFICIAL JOURNAL OF THE NATIONAL GEOGRAPHIC SOCIETY WASHINGTON, D.C.

AS A NURSE in Alaska, Norma Scott was so busy in the years following the great earthquake of 1964 that she stashed some NATIONAL GEOGRAPHIC magazines away, unread. This year, retired in Vancouver, Washington, and "landlocked by a sickly winter," she pulled a box of old GEOGRAPHICS from the barn and read them all. She wrote to tell us she found "Where Jesus Walked" (December 1967) the "most beautifully done article I have ever read. I hope author Howard La Fay is still with you and can be told about this."

We regret to tell you, Mrs. Scott, he is not. Last December 9 this incomparable member of our writing staff lost a long battle with cancer. And we lost the finest writer—and finest friend—many of us have been privileged to know. His last article, "Texas!" (April 1980), reflected both the state and the man himself—big, booming, profane, lyrical, satirical, and poetic.

"The beauty of language and the ideas it expresses stood at the center of his being," said Associate Editor Joseph Judge in his eulogy. "He was a gifted and true artist."

As we approach this season of sentiment and reminiscing, Mrs. Scott's letter reminds us that the GEOGRAPHIC brings you the work and words of many other fascinating and gifted people, too seldom introduced, perhaps too little recognized. Beginning with this issue we inaugurate On Assignment, a one-page feature (preceding pages) to help correct this shortcoming.

You'll meet other talented contributors this holiday season with the publication of our first book on National Geographic photography, *Images of the World*. Among its chapters many of our finest photographers reveal their intellectual as well as technical approach to assignments. Is this much envied job all glamour?

"It's about as glamorous as crawling on your stomach in a snake pit," growls Director of Photography Robert E. Gilka, ". . . as being marooned for weeks on a frozen island in the Bering Strait . . . as trying to change a roll of film with a 150-pound gorilla on your back."

From wherever we are to wherever you may be, I wish you on behalf of the entire staff a very merry Christmas and our very best wishes for a happy New Year.

Wilbur E. Garrett

EDITOR

NATIONAL GEOGRAPHIC

THE NATIONAL GEOGRAPHIC MAGAZINE VOL. 160, NO. 6

December 1981

Mount St. Helens Aftermath 713

Plants and animals are taking tentative foothold in the devastation left by last year's cataclysmic eruption. More remarkably, the blown-out volcano itself nurtures bacteria, reports Rowe Findley. With photographs by Steve Raymer.

Pandas in the Wild 735

From a joint World Wildlife Fund-Chinese research program, U. S. zoologist George B. Schaller brings back unprecedented photographs of giant pandas roaming the forests of their native Sichuan.

Orange, a Most California County 750

Exploding from farmland into glossy exurbs, the coastal swath south of Los Angeles embodies one manner of American dream. By Judith and Neil Morgan and photographer Vince Streano.

The Ocean 780

Jacques-Yves Cousteau, from a lifetime spent in deep-sea research, finds both challenge and hope for man in "the all-encompassing sea."

New World of the Ocean 792

In the past three decades science has revealed startling new knowledge about the seven-tenths of earth covered by the seas. Yet man has barely crossed this watery frontier. Samuel W. Matthews tells of an extraordinary age of discovery.

Life by Night in a Desert Sea 834

A host of rarely seen creatures rises in the dark off Hawaii to feed near the surface. By naturalist Kenneth Brower, with photographer-divers William R. Curtsinger and Chris Newbert.

President's Report to Members 848

Gilbert M. Grosvenor reviews the year past and year ahead, the Society's new Atlas, headquarters building, and TV Specials. In 1981, he notes, membership reached a record 10,850,000.

COVER: *Lovable and rare, the giant panda is considered a national treasure in its native China. Photograph by George B. Schaller.*

MOUNT ST. HELENS AFTERMATH

The Mountain That Was—and Will Be

By ROWE FINDLEY ASSISTANT EDITOR
Photographs by STEVE RAYMER
NATIONAL GEOGRAPHIC PHOTOGRAPHER

AGAINST ALL REASON I feel a touch of panic, but I think I know the cause. Only a year ago this course we are flying would have dashed us onto the crest of Mount St. Helens. I remember its near-symmetrical summit and how it blew away in minutes on May 18, 1980. It is memory's ghost that gropes for the panic button even as we glide high and clear above the broken crown (***foldout, left***).

That crown still steams and smolders. Three sides cradle a fire pit that measures more than two miles long and a mile wide. The fourth—the north side—gave way in the mightiest volcanic landslide ever recorded. Three times since then this volcano has grown lava domes and twice blown them partially away. Now the third and largest dome towers almost 600 feet. Volcano-formed Mounts Rainier and Adams loom on the horizon.

The sight feeds a vague dread of further eruptions. And I hear reports that lakes, enriched by mineral-laden ash, teem with bacteria, including *Legionella*, cause of legionnaires' disease.

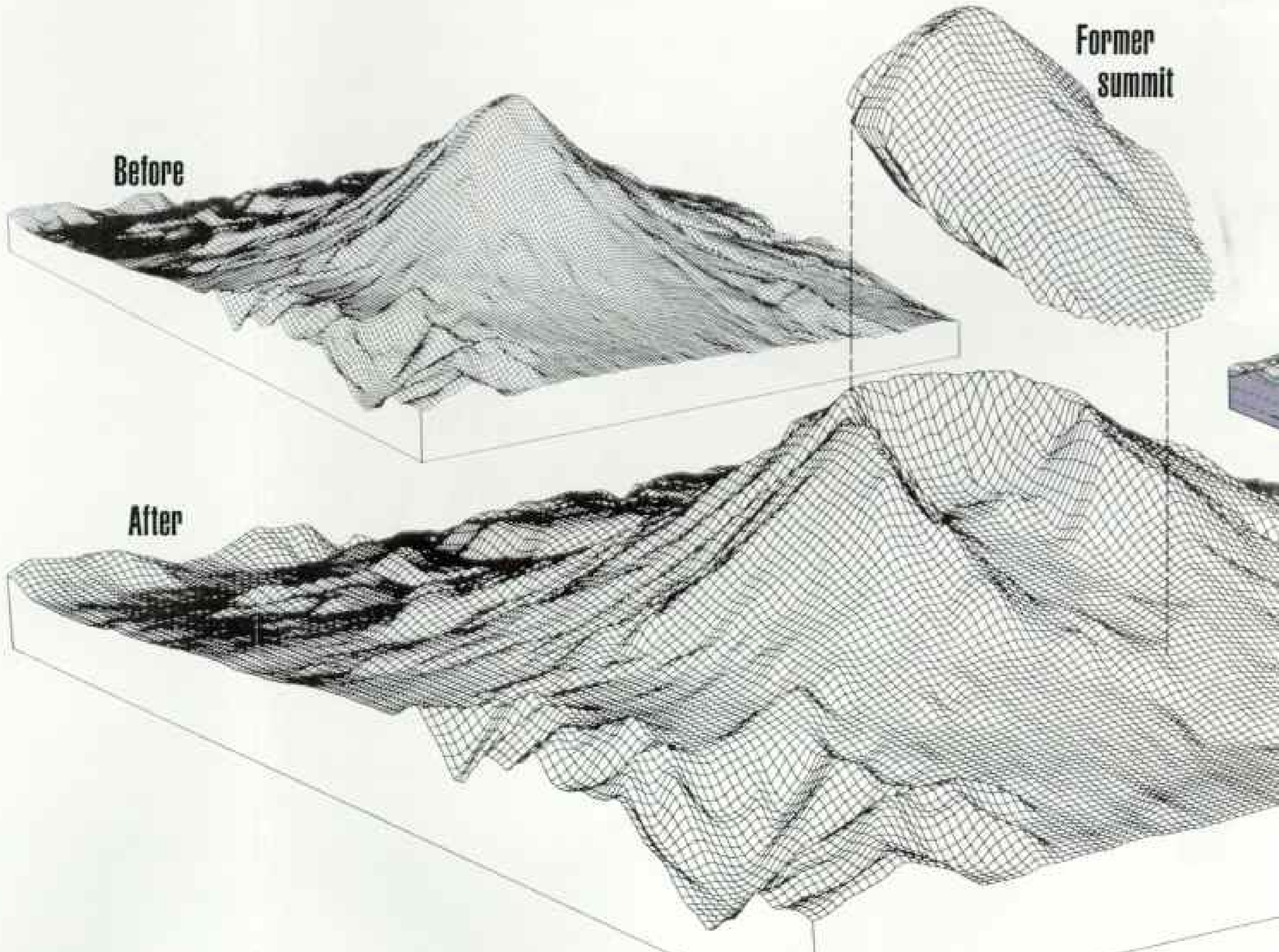
Yet I also learn that volcanoes have spawned far-ranging benefits for earth's soil and air. Earth scientists tell me that this vast swath of destruction can be a crucible of creation.

To destroy and then build up again, that is the trademark of Mount St. Helens. Some four centuries ago the volcano labored for years to shape a cone so nearly perfect that many would liken it to Japan's Mount Fuji. The finishing touch came only in the last century, a two-year labor to add a north-fringe lava dome known as Goat Rocks. Those creations and a few older works were all destroyed on the morning of May 18, when St. Helens blew away almost a cubic mile of its summit, reducing its elevation from 9,677 feet to 8,364 feet.*

These detailed drawings of the mountain and its plumbing, together with a panoramic map on pages 730-31, take advantage of recent advances in computer science. Computer tapes provided by the United States Geological Survey contain average elevations for a given terrain for intervals as small as 100 feet. Digesting the tapes' input, the Prime computer of Dynamic Graphics, Inc., of Berkeley, California, rendered relief drawings in tandem with a Zeta plotter. The plotter consists of four pens, each with different color ink, that translate the computer's pulses into marks on paper.

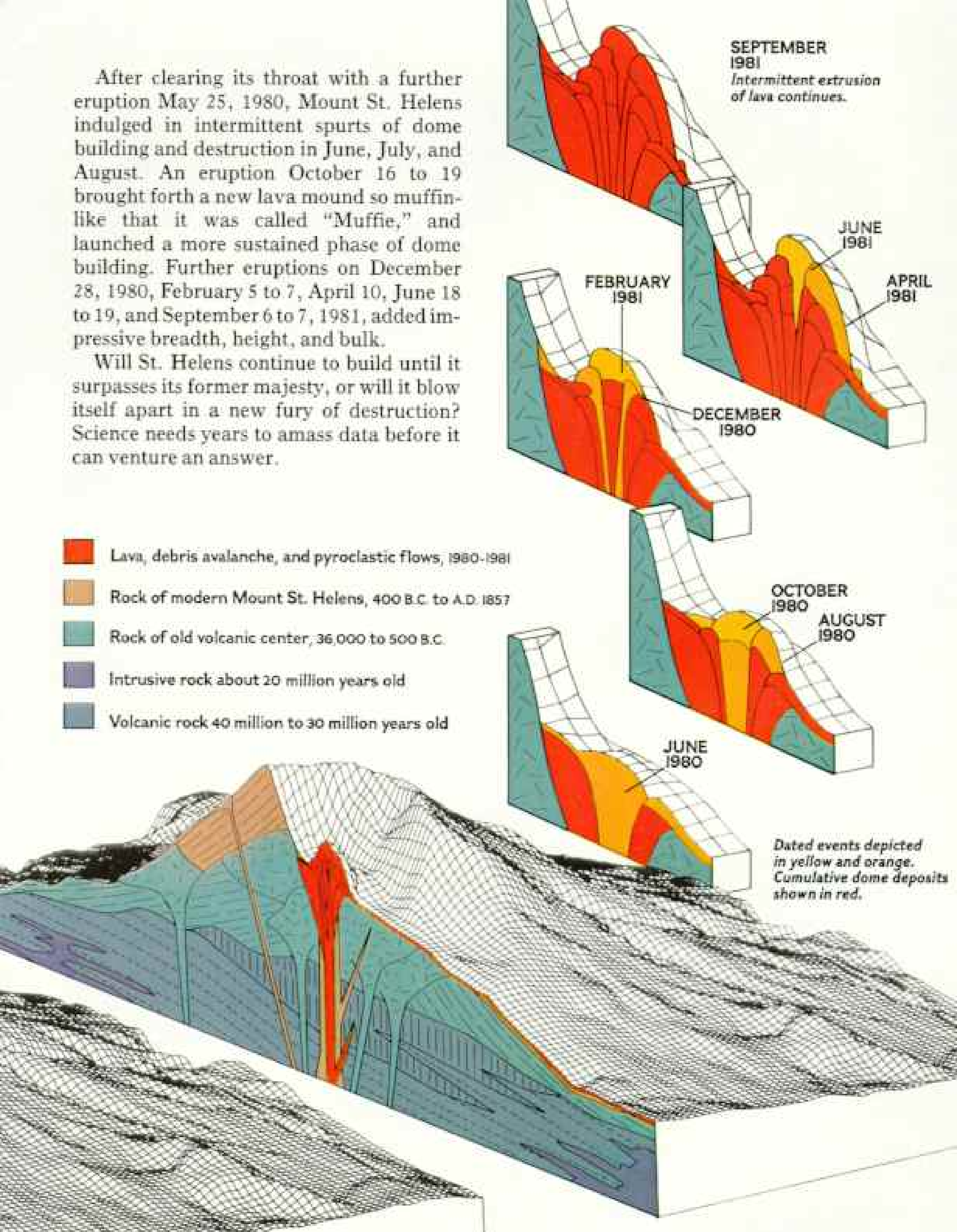
Upon command the computer can change the oblique angle and compass direction of a map to any perspective desired. The vertical scale of these drawings is exaggerated by a factor of one and a half, and the scale for pages 730-31 is exaggerated by two.

*NATIONAL GEOGRAPHIC in its January 1981 issue published a three-part report by the author on the eruption, with pictures by 21 photographers.



After clearing its throat with a further eruption May 25, 1980, Mount St. Helens indulged in intermittent spurts of dome building and destruction in June, July, and August. An eruption October 16 to 19 brought forth a new lava mound so muffin-like that it was called "Muffie," and launched a more sustained phase of dome building. Further eruptions on December 28, 1980, February 5 to 7, April 10, June 18 to 19, and September 6 to 7, 1981, added impressive breadth, height, and bulk.

Will St. Helens continue to build until it surpasses its former majesty, or will it blow itself apart in a new fury of destruction? Science needs years to amass data before it can venture an answer.



COMPUTER MAPS BY DYNAMIC GRAPHICS, INC.
AND UNITED STATES GEOLOGICAL SURVEY

GEOLOGIC DATA FROM MICHAEL DOUGHERTY
UNITED STATES GEOLOGICAL SURVEY
AND CLIFFORD A. HOPSON
UNIVERSITY OF CALIFORNIA, SANTA BARBARA

COMPILED BY DOROTHY A. NICHOLSON
NATIONAL GEOGRAPHIC ART DIVISION

TAKING THE PULSE of a dragon, U. S. Geological Survey scientists go into the steaming crater every clear day (*left*). Helicopters, most flown by Vietnam veterans, land the geologists often within 500 yards of the dome. Wearing a breathing mask, Dan Dzurisin (*right*) measures stresses and the growth of a fissure that jets sulfur dioxide. An insulated glove is very handy for picking up blistering hot, sulfur-encrusted rocks that line some of the fissures with gleaming yellow (*lower right*).

A typical day's schedule calls for scientists Donald Peterson, Donald Swanson, and Christina Heliker to trek around the dome with a surveyor's level, taking readings to detect swelling or subsidence of the crater floor. To supplement their data, Mike Doukas, from a station on the open side of the crater, takes sightings on a network of stakes with a theodolite.

Mike's work is handicapped by the loss of some of his stakes in a recent landslide off the unstable dome. The crater crews are conditioned to keep wary eyes on the awesome mound, which can release a slide at any moment, and on the crater's steep walls, which constantly rattle and rumble with avalanching rock and ice.

In April and June of 1981 the crater measurements detected a pattern of swelling that enabled scientists to issue an advisory of possible eruption as much as two weeks in advance. Then, when seismographs jittered with increasing quakes, some activity was predicted within hours.

"The warnings enabled us to evacuate the red and blue zones that extend some 20 miles from the mountain," said Charlie Caughlan of the U. S. Forest Service. And in both instances the mountain erupted, billowing steam and coughing up accretions to the growing dome of lava.

"We have a lot to learn before we can issue routinely reliable forecasts," Don Peterson, the chief scientist, told me. "But we're making progress."

THE PLACE where Harry dwells, in the memory of friends, is marked by a wooden monument below the mountain that gave him burial (***above,*** left). Harry R. Truman, 84, passed from life into legend when exploding Mount St. Helens, five miles away, unleashed an unprecedented landslide that buried his spacious lodge by Spirit Lake, home of more than 50 years.

Earlier, his refusal to leave despite warnings had brought him national attention and thousands of letters. Since his death, posters, books, songs, and even a movie celebrate his fiercely independent spirit.

And though many friends miss Harry, there is agreement that he would have been very unhappy had he lived to see the tragic end of his once noble mountain and once beautiful Spirit Lake.

More than a year later, the stark gray ashscape appears little changed. Harry's wooden cross stands beside a huge pool formed when water trapped underground heated and blasted upward, forming a crater. The pool bubbles with methane gas, a spirited brew that reminds those who knew Harry of the three dozen bottles of his favorite bourbon lost with him.

The marker was made and erected by Harry's sister and brother-in-law, Geri and Buck Whiting of Castle Rock, Washington. Buck chose the site of the former lodge for the memorial. "Next year there'll be a monument of bronze and stone," he told me.

JOHN MARSHALL (ABOVE)

Harry remains on a list of presumed dead, one of 20 in that category out of 60 persons lost. Also on the list is John Killian, 29, a Weyerhaeuser Cat operator. He and his wife, Christy, 20, were at remote Fawn Lake, ten miles northwest of the mountain when it blew. At first neither of them could be located, but Ralph Killian, father of John and a Weyerhaeuser foreman, would not give up. After he found a piece of their pickup truck, a search party discovered, on July 17, where Christy had died, and the family placed these flowers near the spot (***right***). Ralph has vowed to keep looking every spare minute until he locates the body of his son.

WORLD'S BIGGEST clear-cut, 230 square miles of timber lay in tangles after the cataclysm. As much as 140 square miles may be preserved in an interpretive area. On the rest the Weyerhaeuser Company and the Gifford Pinchot National Forest are conducting a massive salvage operation. Flying over the jumble (***left***), I soon lost count of the log-laden trucks threading the mountain roads.

"We're hauling out 500 loads a day," Weyerhaeuser forest engineer Jim Rombach told me. The U. S. Forest Service is letting contracts, Gifford Pinchot supervisor Bob Tokarczyk said, that will total 771 million board feet of lumber. The combined harvest could build 77,100 three-bedroom homes.

The abrasive ash poses hazards to workers and their machines. Chain saws dull quickly when biting ash-covered wood (***above***). And when the wind blows or equipment churns up dust, face masks protect crews. To monitor long-range effects, employees are being examined periodically by health authorities.

EXPLOSION of yellow shows new growth over the ash gray devastation area in this composite satellite image from space (***left***). Bright blue indicates expansion of lakes in a year's time, especially Coldwater Lake, at ten o'clock from the crater. Flows of debris from the volcano created Coldwater and other lakes by damming tributary valleys.

Ancient symbols of resurrection, avalanche lilies help heal the earth (***right***), as does a variety of other reviving vegetation: trailing blackberry, pearly everlasting, lupine, and bracken fern. Man helps by setting out trees—last spring some two million on 5,000 acres, principally by Weyerhaeuser with some plantings by the Forest Service.

Planting trees in ash is a problem, and colored tags help Weyerhaeuser crews test results in an experimental plot, whose lushest plants are clumps of volunteer fireweed (***lower right***). "The ash lacks nitrogen, and seedlings set totally in ash are almost sure to die," Jack K. Winjum of the firm's Mount St. Helens research project told me.

Where the ash lies several inches deep, tractors have scarified the land to get seedling roots into soil, and wood shingles stuck in the ground shade seedlings set in heat-reflective ash.

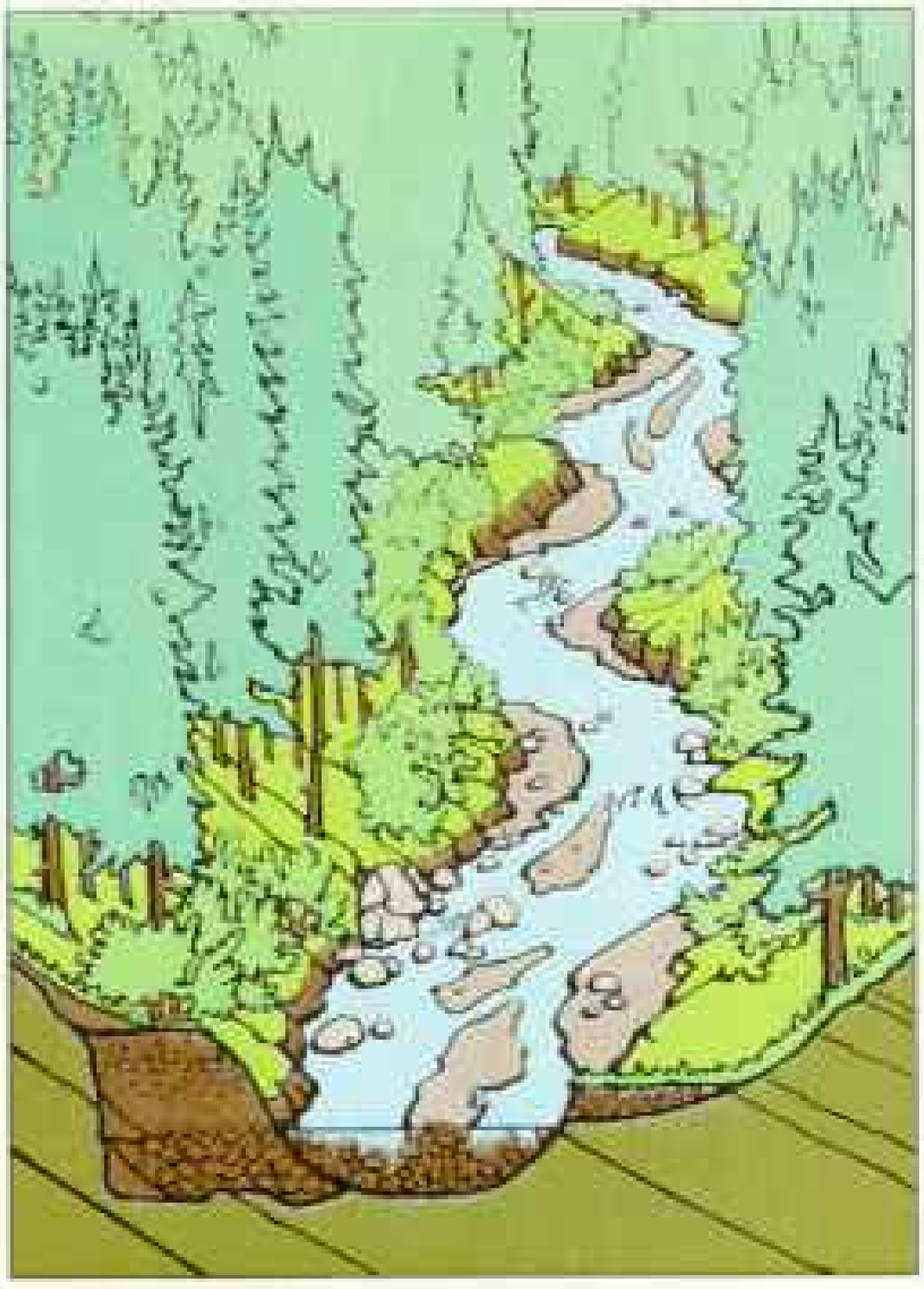
Most of the ten million fir seedlings to replant the gray land are being grown at the Forest Service's Wind River Nursery. There assistant nurseryman Dave Dutton pointed out long shade sheds where controlled heat and moisture convert the seeds to plantable trees in only six months. The nursery uses a minimum of pesticides, a maximum of natural fertilizers, and 26 weed-eating Chinese geese to aid cultivation.

NASA, GODDARD SPACE FLIGHT CENTER (LEFT); JOHN MARSHALL (ABOVE AND BELOW)

ELK RECLAIM A WASTELAND in the Toutle Valley, where a few leafing hardwoods and sprigs of grass promise the eventual return of bounteous forage. This herd's passage contrasts with the stillness that reigned a year before; May 18's

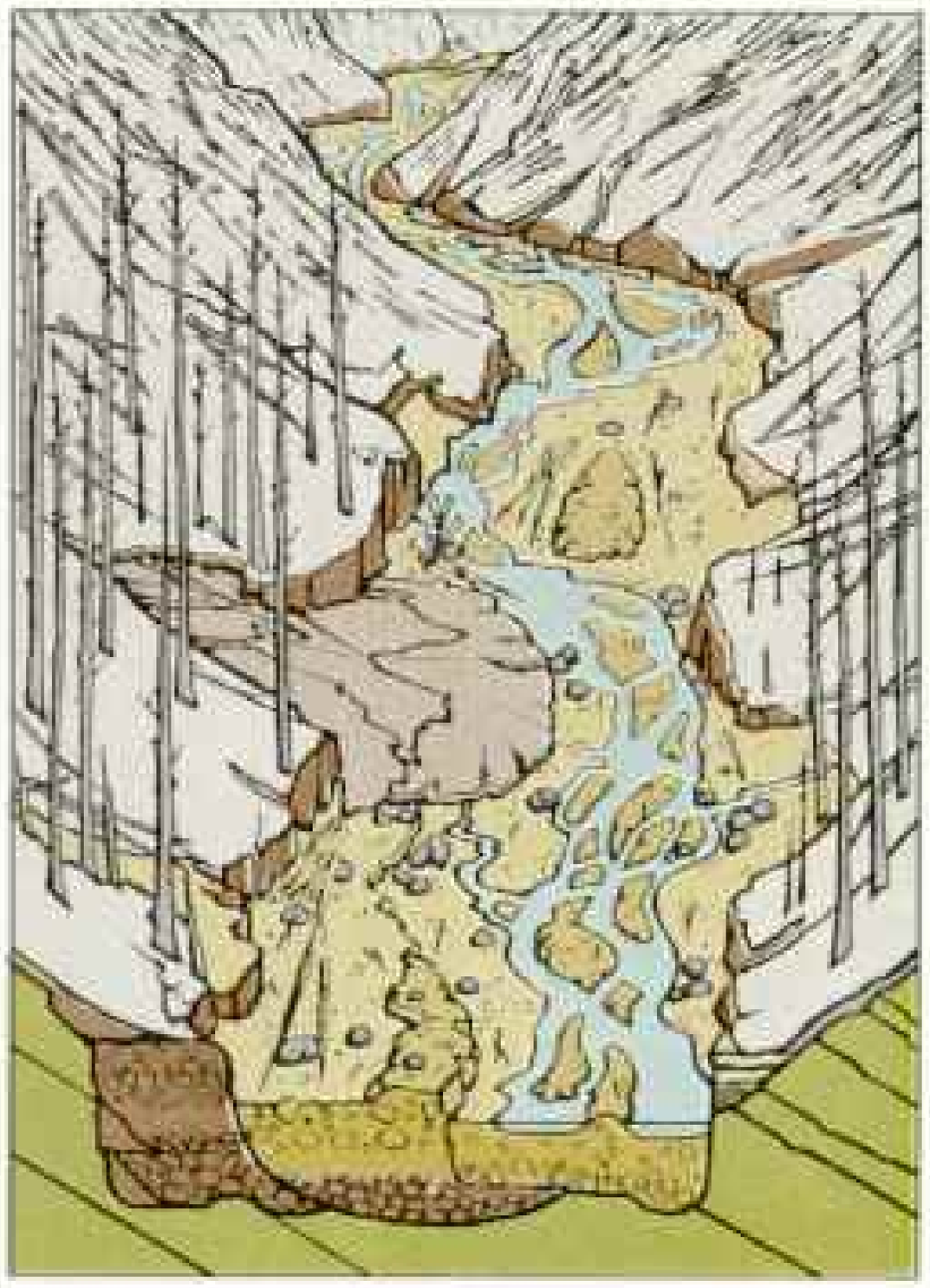
JOHN MARSHALL

explosive scythe killed an estimated 5,000 black-tailed deer, 1,500 elk, 200 black bears, 15 mountain goats, plus unknown numbers of mountain lions, bobcats, small rodents, birds, fish, and insects. "We lost our entire population of spotted owls north of the mountain," Forest Service wildlife biologist Bill Ruediger told me. But resurging life gradually shrinks the volcanic desert. I heard a mountain bluebird's song and the killdeer's call, saw many deer tracks and scurrying ground squirrels and gophers.



Before the eruption 1980

After the eruption 1980



NATIONAL GEOGRAPHIC ART DIVISION

Spring 1981

Harnessing streams gone wild

IN EASY CYCLES with the seasons, a pristine river adjusts to drought or deluge (***diagram, far left***). Forested watershed retains a maximum of rainfall and rations out runoff in dry times. The meandering stream of alternating pools and rapids has developed a natural pavement on its bottom through floods' repeated scourings that leave only heavier rock and sands. Thick riparian vegetation stabilizes banks.

Transformed by debris from the volcano, the same stream lies gutted and vulnerable to every freshet's runoff (***middle diagram***). The bottom pavement has been ripped away, most of the channel is clogged, and over that the new stream flows straight, cutting off meanders and carving steep banks devoid of soil-holding vegetation. A watershed of dead and downed trees and near-impervious ash multiplies runoff.

After a winter of rains and snowmelt runoff, the stream is even more debris filled (***diagram, near left***). Its single channel has become braided into many, cutting away embankments, being diverted around alluvial fans of debris from tributary valleys.

An example of a stream running wild, the Toutle River nibbled threateningly at these bridges (***below left***) on May 18, 1980, when the maelstrom of water and ash and rock unleashed by St. Helens swirled to within inches of swallowing the spans. I saw the tense drama from a plane while freight trains waited and traffic halted on Interstate 5.

Now the bridges, where the Toutle, at left, and Cowlitz Rivers meet, stand at the pivot of the largest and costliest emergency project ever undertaken by the U. S. Army Corps of Engineers. With the price tag rising past a quarter of a billion dollars, the Engineers have moved 100 million cubic yards in only a year and a half—a third of the material excavated in 24 years for the Panama Canal. They have redug the Columbia River's clogged channel, restored 70 percent of the carrying capacity of the Cowlitz, and built several debris dams, sediment traps, and miles of levees.

Vigil on flood and quake

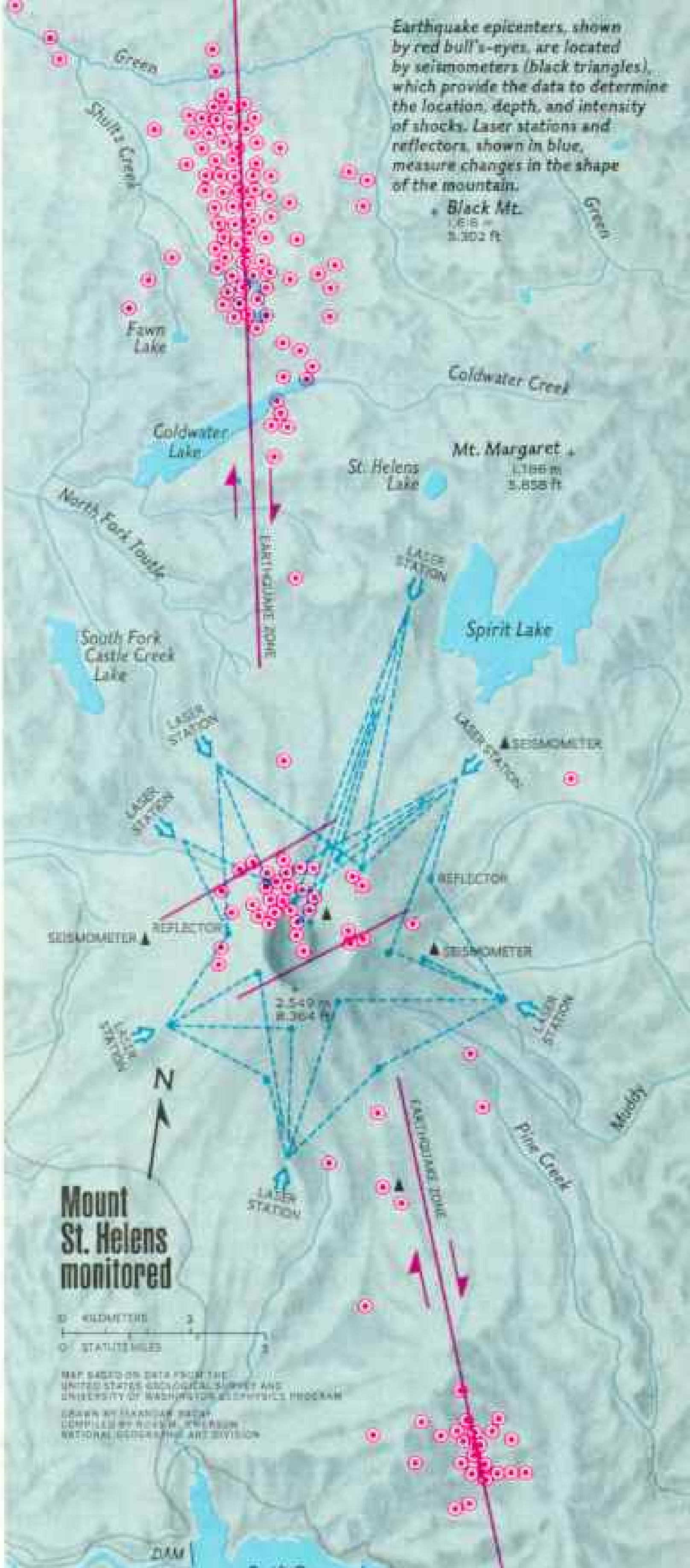
THE MASSIVE FLOW of debris that swept down the North Toutle Valley raised its floor as much as 600 feet, damming tributary valleys and creating new lakes and ponds. The largest, Coldwater Lake, continued to rise, and U. S. Army Engineers foresaw that it finally would top its natural dam. The dam then might erode swiftly, releasing a deluge down the Toutle and Cowlitz Rivers, overwhelming low areas as far as Kelso and Longview.

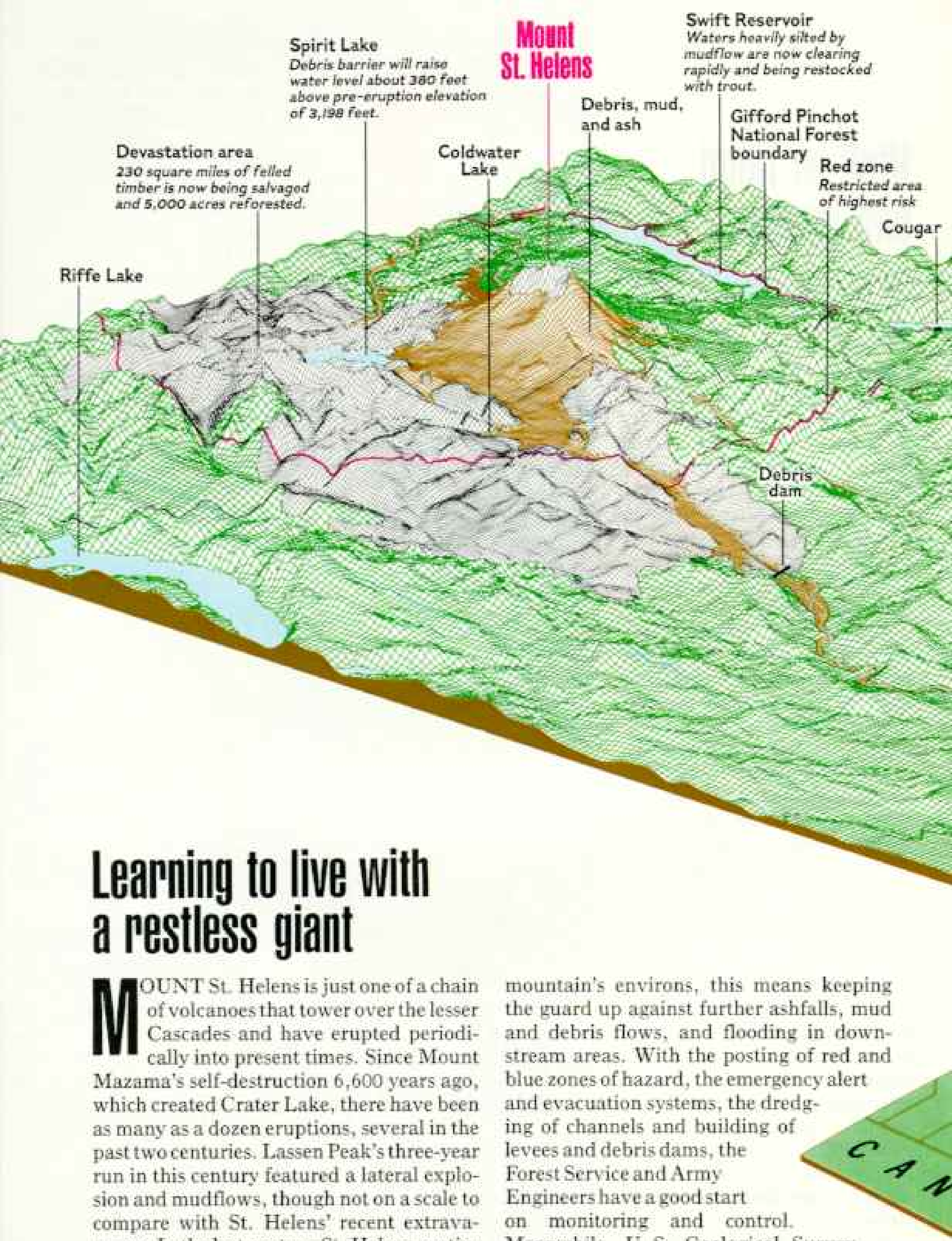
To lower the lake to a safe level, an exit channel was dug in just 14 weeks last summer. Working night shifts, sometimes bogging to their axles in mud, huge earth-moving machines finished the 3,000-foot-long channel (***left***) on schedule despite small delays, one for evacuation of workers when the volcano erupted.

Monitoring earthquakes is a more complex problem (***right***). Seismologists found the pattern of quakes increasing in diversity following the big eruption on May 18. What had been a general north-south configuration was interrupted by an east-west trend on and near the mountain. Scientists seek to determine if there is a relationship to western Washington's historic earthquake zone, which in 1949 experienced a quake measuring 7.0 on the Richter scale that centered on Olympia.

A network of laser reflectors and transmitter sites on and near the volcano helps detect changes in the face of the mountain.

RALPH PERRY (LEFT)





Learning to live with a restless giant

MOUNT St. Helens is just one of a chain of volcanoes that tower over the lesser Cascades and have erupted periodically into present times. Since Mount Mazama's self-destruction 6,600 years ago, which created Crater Lake, there have been as many as a dozen eruptions, several in the past two centuries. Lassen Peak's three-year run in this century featured a lateral explosion and mudflows, though not on a scale to compare with St. Helens' recent extravaganza. In the last century St. Helens continued its volcanic venting from 1831 to 1857. History's lesson, then, is not to expect an early shutdown by St. Helens. For the mountain's environs, this means keeping the guard up against further ashfalls, mud and debris flows, and flooding in downstream areas. With the posting of red and blue zones of hazard, the emergency alert and evacuation systems, the dredging of channels and building of levees and debris dams, the Forest Service and Army Engineers have a good start on monitoring and control. Meanwhile, U. S. Geological Survey and University of Washington scientists must continue to monitor the mountain's vital signs into the indefinite future.

Toutle River
Excavation of eight sedimentation basins in the Toutle River helps limit silting of the Cowlitz River.

Cowlitz River
Removal of 56 million cubic yards of sediment has restored channel flow to 70 percent of former capacity.

Flood protection
Seven miles of levees along the Cowlitz River have been constructed or reinforced to protect Longview, Kelso, Lexington, and Castle Rock.

Columbia River
Continuous dredging removed 15 million cubic yards of sediment to reopen a 40-foot-deep navigation channel.

Longview
36 miles from Mount St. Helens

Yale Lake

Debris dam

Blue zone
Restricted area

Lexington

Kelso

Toutle

Silver Lake

Castle Rock

Interstate 5

Toledo

Vader

Winlock

LOOKING SOUTH

SAN ANDREAS FAULT

LASSEN PEAK
1914-1917

CRATER LAKE
ca 4850 B.C.

MT. SHASTA
1786

MT. HOOD
1865, 1907?

MT. JEFFERSON
ca 950

THREE SISTERS
ca 150 B.C.
ca 950

Mount St. Helens

MT. ADAMS
ca 100

MT. RAINIER
1882?

GLACIER PEAK
ca 950

MT. BAKER
1843, 1870

Portland

Seattle

Vancouver

Vancouver Island

CALIFORNIA

OREGON

WASHINGTON

NORTH AMERICAN PLATE

LOOKING SOUTH

The active Cascades

Mt. Baker to Lassen Peak, 580 miles

Question marks mean eruption uncertain.

COMPUTER MAP BY DYNAMIC GRAPHICS, INC.
AND UNITED STATES GEOLOGICAL SURVEY

COMPILED BY DOROTHY A. NICHOLSON
AND ROSS M. EMERSON
NATIONAL GEOGRAPHIC ART DIVISION

TO PROBE A PARTNERSHIP of life and death, microbiologists collect green slime from the streams near Mount St. Helens (***below***). Actually a complex community of life, these blue-green algae, as they are commonly known, proliferate in the nutrient-rich water—minerals supplied by the volcano itself.

In lakes and streams, the nutrients also nurture a pathogen perilous to man and not all that rare in our environment, the bacterium *Legionella*. It was named after the outbreak in 1976 of respiratory illness at an American Legion convention in Philadelphia, Pennsylvania. The epidemic killed 29 and sickened 180. It took four months for researchers at the Center for Disease Control in Atlanta to isolate the culprit.

Though the illness, which produces pneumonia, now yields to medication, I still respected its threat on a day last summer when I went with Oregon State University microbiologist John Baross to the North Toutle Valley. In hopping across a rivulet, I suddenly sank to my knees in water-saturated ash and worried about contamination. But John soon diverted me with a rival worry by revealing that a colleague at this same spot a month earlier had sunk to his chin and required instant rescue. With that knowledge, I gave equal time to both anxieties.

My concern about *Legionella* was intensified by the fact that National Geographic photographer Steve Raymer three weeks before had suffered chest pain, headaches, and fever. Penicillin seemed to have no effect on the symptoms, but they faded after dosages of erythromycin, a standard prescription for legionnaires' disease as well as other bacterial infections. Another aquatic biologist, Jim Sedell, had three times become sick with similar complaints.

Through dangerous summer months, when warmer waters favored *Legionella*'s bloom, Dr. John Kobayashi, medical epidemiologist for Washington State, carefully monitored blood samples submitted in respiratory cases. At summer's end, no cases had been confirmed.

But in the minds of many scientists, such threats to human health were far outweighed by the prodigious explosion of algal and bacterial life in the wake of the eruption. Popular belief held that the bombardment of the lakes and rivers with ash and rock as hot as 600°C had sterilized all the waters near the volcano. But the heating turned out to be below a sterile absolute, and volcanic materials actually provided the ingredients for a chemical broth of life.

Though decayed wood from forests that toppled in the explosion may supply some organic sustenance, many of the simple life forms found here feed on minerals alone. John Baross has studied similar life processes that take place a mile and a half down in the Pacific Ocean around hydrothermal vents of the East Pacific Rise. He and his colleagues concluded that the marine bacteria there were similar in structure to fossil organisms found in Precambrian rock—dated more than three billion years old.

For a further wonder, Dr. Baross has found these same life forms on rocks in the crater itself, rocks crusted with iron oxides, manganese, or sulfur (***above***). A scanning electron microscope shows filamentous bacteria on such rocks (***right***).

"They must be living on chemistry alone," he told me. "There's nothing organic to

JOHN MARSHALL

sustain them there. But how they got there in the first place is a fascinating question."

And thus I grow in appreciation of the volcano as shaper and sustainer of earth:

- With earthquakes and shifting plates, volcanism is the great uplifter of the land, fathering mountains, restoring dynamic gradients in what erosion otherwise would reduce to a low plain.
- Volcanic outthrowings have provided the gases of our vital atmosphere and land and waters that harbor life.
- Fine volcanic ash in the high atmosphere can regulate the solar heat and energy reaching the surface, and some scientists studying long-range climate patterns see volcanism as the thermostat of the planet.

These are factors to counter the inevitable toll to human lives—an estimated 200,000 worldwide in 500 years—as we try to weigh volcanism on creation's scale of values.

To me the ultimate wonder is that some of the rock under John Baross's feet is as new to the surface of our planet as was the first ever formed. □

R. H. SOELDNER AND JOHN BAROSS, OREGON STATE UNIVERSITY

FOR THE FIRST TIME A WESTERNER JOINS CHINESE SCIENTISTS TO STUDY

Pandas in the Wild

TEXT AND PHOTOGRAPHS BY
GEORGE B. SCHALLER
DIRECTOR, ANIMAL RESEARCH AND CONSERVATION CENTER, NEW YORK ZOOLOGICAL SOCIETY

FRESH TRACKS in the snow pass within 100 feet of my tent. Nearby another set of tracks tells of a smaller animal moving in the same direction. All day my Chinese associate and I trace their route. Then, on a late winter afternoon, we spy a small black-and-white creature almost invisible on the bough of a spruce. Below sits a more massive animal. Finally. After two months in the rugged Wolong Natural Reserve in the mountains of China's Sichuan Province (map, page 741), I have seen my first giant pandas in the wild.

Chinese experts estimate that the total panda population today may not exceed 1,000. More than 100 starved to death in the mid-1970s, when one of the species of bamboo on which they feed bloomed and died in a large section of their habitat. Worried about the decline of the pandas, the Chinese, who count *Ailuropoda melanoleuca* a national treasure, invited the World Wildlife Fund, whose symbol is the panda, to join in a research and conservation program to study this rare, shy mammal.

I was asked by the World Wildlife Fund to participate in the field research. After the first six months of the study, I realize that there are still more questions than answers about the behavior of this animal everyone loves.

THE BIRCHES around our camp are heavy with frost and shine like transmuted starlight against the dawn sky. The thermometer outside my tent measures 14°F.

I set out to look for fresh panda spoor with Hu Jin-chu, a professor at Nanchong Teachers College and one of Sichuan's best naturalists. Professor Hu serves as field director for the study. The trek is an arduous task because of the rugged terrain and dense thickets of bamboo.

We climb to search a ridge we have not visited for a week. Our camp lies at 8,300 feet. Pandas roam to 10,500 feet and higher—as far as bamboo persists. Though gripped by winter cold, the forest is strangely verdant. There are spruce and hemlock, and beneath them rhododendron and whole slopes of bamboo, all in green leaf, as if summer has been momentarily suspended.

Professor Hu leads the way across a treacherous hillside (*left*) where seepage has turned into a frozen chute.

When we find tracks, they are traced on plastic (*below*). By noting each footprint's idiosyncrasy, we may be able to identify individuals from their tracks. We like to follow the exact route of an animal to determine not only where it has fed, but also to note every bamboo stem it has eaten.

Droppings and compressed bamboo mark a panda sleeping site (*below*), which Professor Hu tries out for size. In our nine-square-mile study area, there are seven pandas, although one or two more may wander in from time to time.

A SIGNPOST reads "panda in the area." No one knows why pandas claw trees (***below***). It may be to sharpen or clean their claws, and perhaps to signal their presence. This is the work of one of three wild pandas we track by radio collar. One afternoon I hear her crunching a bamboo stalk. With her keen sense of smell, she quickly becomes aware of me. Possibly curious, she draws to within 35 feet to look me over (***left***), and then casually ambles over to a nearby patch of bamboo and goes to sleep.

As winter disappears, the panda's distinctive coat seems to grow more and more conspicuous. When a panda suddenly appears out of the forest, its coat seems to glow. The healthy adult panda has no enemies other than man. Only the young or old and weak may fall prey to such predators as leopards and Asiatic wild dogs.

SNOW retreats up the ravines and ice vanishes from the banks of streams. Flocks of blood pheasants break up to nest and sunbirds return from warmer climates. Birches are leafing out and the rhododendrons burst into bloom.

My wife, Kay, welcomes spring by transcribing her notes out of doors (***left***). The tent pipe goes to a stove that not only keeps us warm but also dries panda droppings we analyze for content.

Nearby is the central shed with our community kitchen, where my Chinese colleagues (***bottom***), including Professor Hu, second from left, and biologist Pan Wenshi of Beijing University, third from right, toss a farewell party for a departing team member.

The 770-square-mile Wolong Reserve is the largest of ten preserves set aside by the Chinese government in its immense efforts to protect the panda. In prehistoric times this bearlike animal with some raccoon characteristics roamed much of eastern China. The dashed line on the map shows the extent of fossil finds. The small red areas are the extent of panda habitat today.

HOW FAR do pandas roam? Are they active both day and night? To answer these and other questions, we need to monitor them with radio-equipped collars. Although pandas eat bamboo almost exclusively, they are also carnivorous, albeit too slow to catch most animals. Wang Xue-quan (***below***) smokes mutton in front of a log trap baited with meat, hoping the smell will lure a panda. After days of checking empty traps, we are electrified by the news that a panda has been caught. We discover an elderly female that we name Zhen-Zhen, meaning "precious" or "rare treasure." After we tranquilize, examine, and collar her, we allow her to recover in the trap and then release her. When she realizes she is free, she trots off (***right***). Not the least intimidated by her experience, Zhen-Zhen entered traps three more times.

HIS NAME is Long-Long, meaning "dragon" (***above***), the only male we captured. Professor Hu, Peng Jiagan, and Howard Quigley, a radiotelemetry expert from the New York Zoological Society, weigh the young 120-pound male. By his weight and teeth we estimate he is 2½ years old.

Ning-Ning, another subadult, lives up to her name, "kind and peaceful," when greeted by Emil Dolensek (***top right***), the society's chief veterinarian, who came to Wolong to work with the Chinese in captive management programs. Pandas are known to be rather unaggressive in the wild, but these subadult animals are so

docile they seem almost like pets.

Signals from the radio collars Howard put on Zhen-Zhen (***left***) and others can be detected several miles away.

The specially adapted panda forepaw (***above***) can clutch a bamboo stem between the five fingers and the elongated wristbone at upper left that is, in effect, a sixth digit.

LAST REFUGE of the panda, this haunting fastness in central China is washed by prolonged summer rains (***left***). The animal's prehistoric range probably became more arid, and later cultivation destroyed its habitat. It survives only in these mountains where the moisture-loving bamboo still thrives. And pandas need a lot of bamboo. Because their digestive tracts extract little nutritive value from the plant, they consume prodigious amounts, spending 50 to 75 percent of the day feeding. Captives have been known to eat 40 pounds of bamboo a day.

For much of the year Wolong pandas keep to higher altitudes, where there are large stands of *Sinarundinaria*, one of the types of bamboo in the study area. In spring some descend to relish the shoots of another kind (***right***). The panda peels the hairy sheath to reach the juicy center—a delicacy also enjoyed by our team.

To eat a long shoot, a panda in the captive breeding facility at Wolong snaps it in two (***above***). Inserting one piece at a time, it will crunch each rapidly—like a sharpener consuming a pencil.

ZHEN-ZHEN is restless, according to our radio signals. Listening from a nearby ridge, we can hear a male emitting the whines and barks that are the equivalent of a panda love song. The next day I observe the pair, and soon see a smaller male arrive. The larger male, threatening and charging, soon drives him away from the female.

I stand near a large fir tree and shortly Zhen-Zhen comes panting up the trail (***top***). Unalarmed, she goes to the other side of the tree and sits down. Soon the male comes puffing up the slope, and I back off. He simply steps

over my tape recorder and follows her. He puts a foreleg on her side as if to induce her to crouch down (***above***). Then she sinks to her elbows and places the top of her head on the ground, allowing him to mount (***lower left***). I observed him mount her 48 times in three hours. It will be perhaps five months later before Zhen-Zhen produces a cub, if at all. If she does, we will carefully avoid her den site for fear of disturbing her.

The knowledge we gain over the next few years will, we hope, preserve the panda in the wild as well as improve breeding in captivity. □

Orange, a Most

By JUDITH AND NEIL MORGAN

OUR BOAT LURCHED through dark waves in grottoes below Disneyland. Cannonballs thundered from computerized pirate ships; docks and forts were set ablaze. As we passed phantom captives, groaning in plastic irons, Ron Dominguez leaned close and shouted:

"This is where I was born! Just above here! Back then, in 1935, my folks' orange grove was right over us! My mom's folks had settled here soon after Orange County split off from Los Angeles in 1889."

Since Walt Disney came down from Los Angeles in the 1950s and bought out the ranchers, Ron Dominguez has advanced on the site from farmhand to ticket taker at Disneyland, and now is its vice president of operations. Donald Duck works for him, and Mickey Mouse and Minnie, and, in summer, 7,500 more.

"It's been so fast," he told us. "Before Disneyland opened in 1955, all us farmers went into Anaheim on Saturday nights and knew everybody. Then all of a sudden everything changed."

For the two million people of Orange County such change, a bizarre and dizzying alchemy, has transformed this southern California coastal oval, long overlooked between Los Angeles and San Diego, into a real-world Tomorrowland.

Its essence is its incongruity, a blend of almost feudal ranch life and Orwellian futurism. Within its borders, besides the cowboys and farmers on the giant Irvine Ranch, are walled and gated clusters of multimillion-dollar homes and miles of industrial and office parks that throb with high technology and optimism.

Ron Dominguez is a rare link between the fantasies of California, past and present. His ancestors have lived on this land for some 200 years, descending from Catalonia-born José Antonio Yorba, who came with the Spanish Army to colonize California in 1769. He sees Orange County as the focal point of a new southern California, one that can still live up to the golden legend: sunshine, fun, wealth, freedom.

More than half the size of Rhode Island, Orange County retains a baronial and pastoral mien—not unrelated to its reputation for ultraconservatism. Politicians used to say that rich, homogeneous Orange County was the place good Republicans go to die. (Its voters chose Democrat Jerry Brown for governor in 1978 but swarmed back more than two to one for Ronald Reagan for President in 1980.) *(Continued on page 757)*

Back-door yacht in Newport

Beach echoes the boom of Orange County, where the California dream has docked.

California County

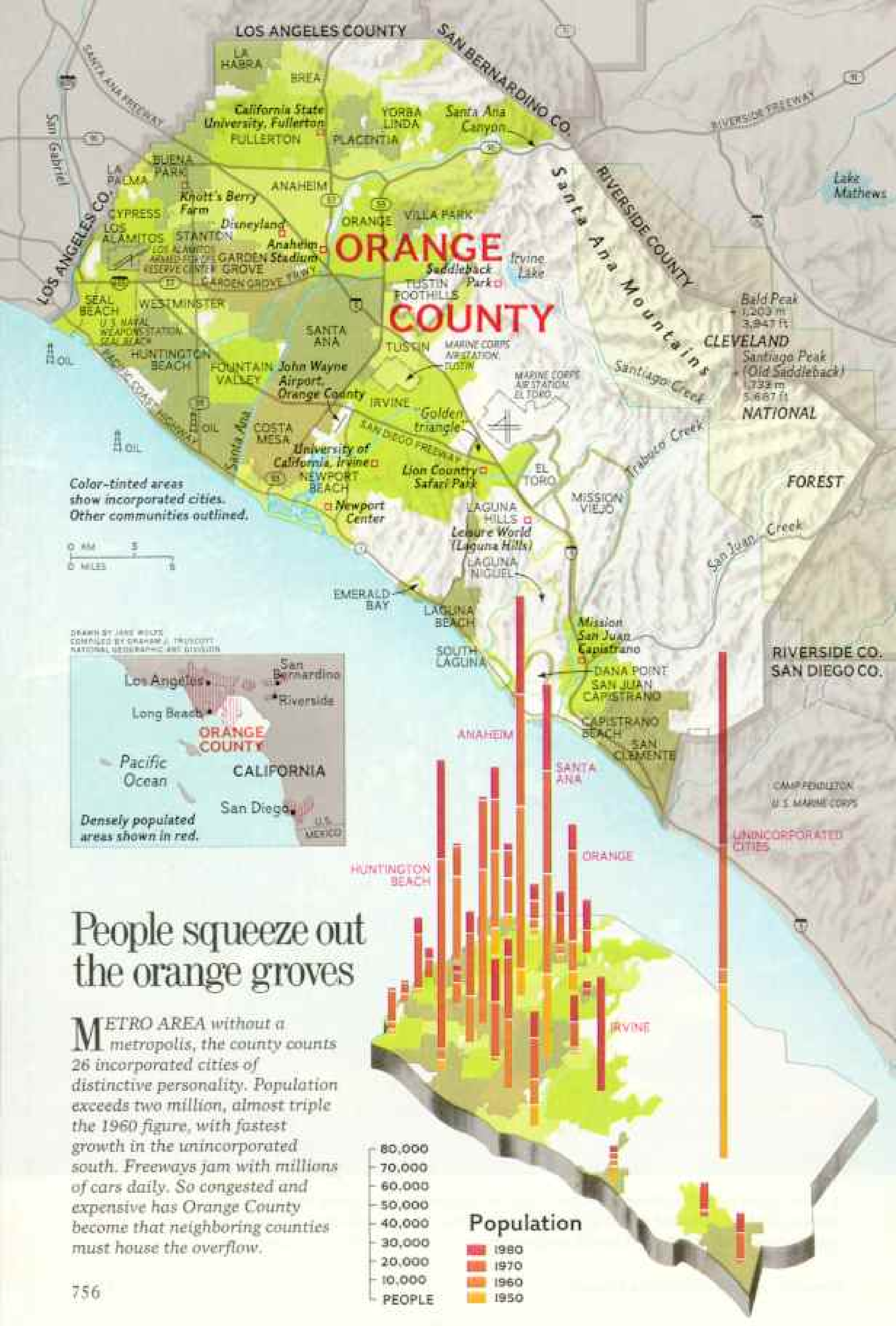
Photographs by VINCE STREANO

Land rush on a gold coast: *For decades newcomers to California have been drawn to Orange County, with its Mediterranean climate and spectacular shore. Here in the Newport Beach to Laguna Beach area the influx continues, as the Irvine Company, the county's largest rancher and major landholder, opens more coastal hills to luxury development. Plans include ocean-view hotels, estates,*

and parkland on the still empty stretch to the south. The company's Newport Center, left, places high offices behind an oval of shops, giving each building a view. Much of the county has been transformed—from Spanish rancho of the early 1800s to citrus grove; from bedroom for Los Angeles in the 1940s to modern metropolitan area, home of high technology and high incomes.

Reaping the blessings *of Orange County's climate, the Crystal Cathedral of Garden Grove Community Church shines under 10,660 panes of glass. An 82-foot-long flag above the altar marks Fourth of July in the church, which can seat only*

a third of its 10,000 members. Walls beside the pulpit open to allow worshipers parked in their cars and tuned in by radio to see the Reverend Robert H. Schuller, who started this Reformed Church congregation in a nearby drive-in theater.



People squeeze out the orange groves

METRO AREA without a metropolis, the county counts 26 incorporated cities of distinctive personality. Population exceeds two million, almost triple the 1960 figure, with fastest growth in the unincorporated south. Freeways jam with millions of cars daily. So congested and expensive has Orange County become that neighboring counties must house the overflow.

(Continued from page 750) The northern third of Orange County, adjacent to Los Angeles, is a jumble of spilled-over towns with imperceptible borders. There are 26 Orange County cities, none with more than 225,000 residents, Anaheim being the largest. Like the begats of the Book of Genesis, they merge: Anaheim becomes Garden Grove and Garden Grove becomes Santa Ana; Santa Ana becomes Tustin and Tustin becomes Orange.

Across the center of the county lies the Irvine Ranch, a 77,000-acre checkerboard of ranchland, orderly communities, and industry. The ranch, which its master planner, architect William Pereira, calls the nation's largest planned urban complex, sweeps from the millionaires' coast to bare gray mountains rising higher than 5,000 feet: a swath 22 miles long and between 4.5 and 9.5 miles wide.

Spanish Flavor Under Siege

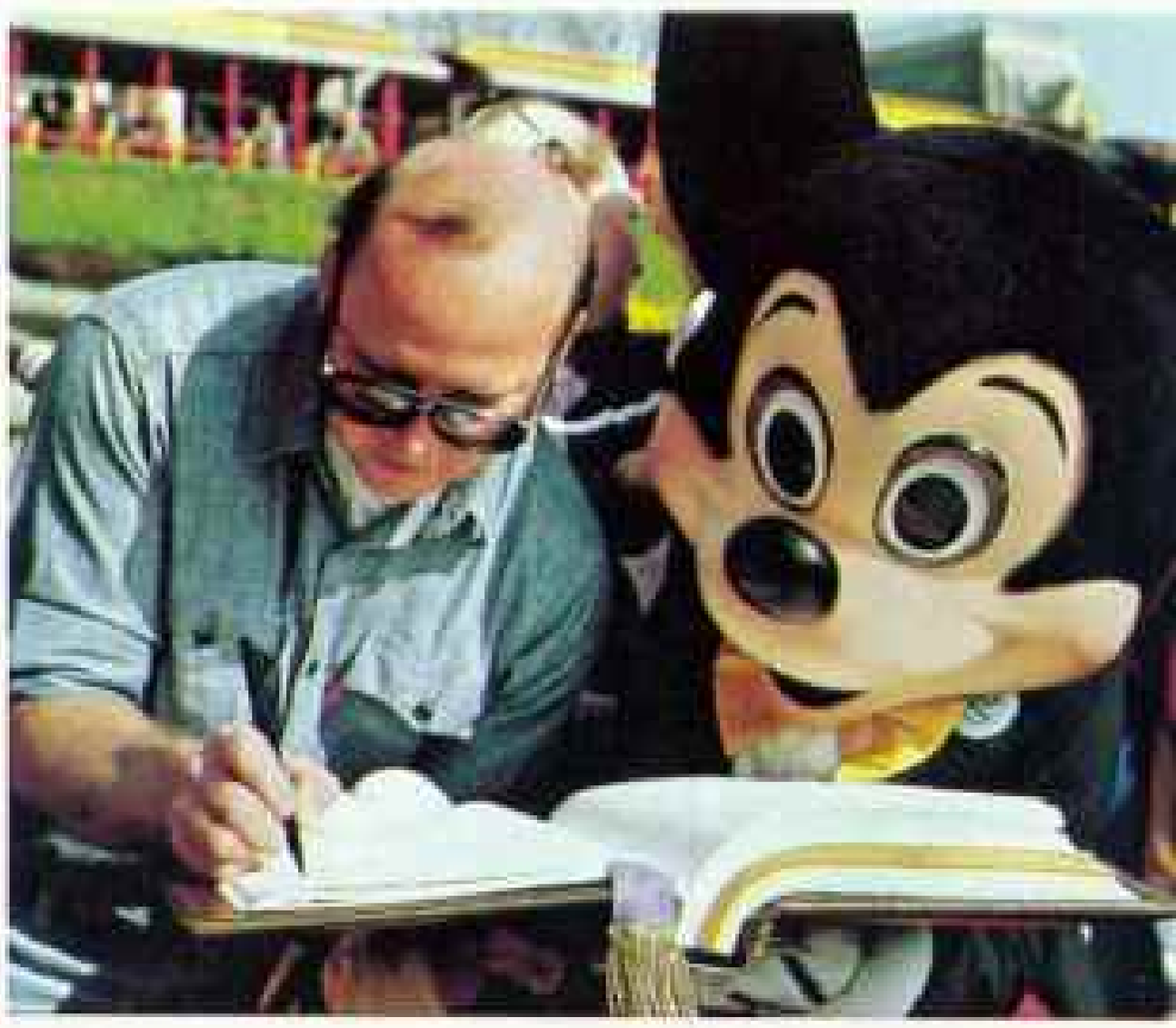
The southern third of Orange County retains a quieter Spanish influence, although convoys of yellow earthmovers race across its horizon like herds of crazed gophers, turning ranchland into grosses of expensive tract homes. Raw exposed dirt is the emblem of Orange County, and the black clouds on some days are only puffs of airborne earth. Open rangeland lies in wait for the oncoming Sunbelt migration.

All along the county's 42-mile coastline of coves and cliffs are sleek and chic communities laced with silvery public surfing beaches. From Huntington Harbour and Newport Beach south to Laguna Beach and Dana Point are aristocratic homes for those who scorn aristocracy, and at their docks are the 12,000 yachts that mirror their opulence.

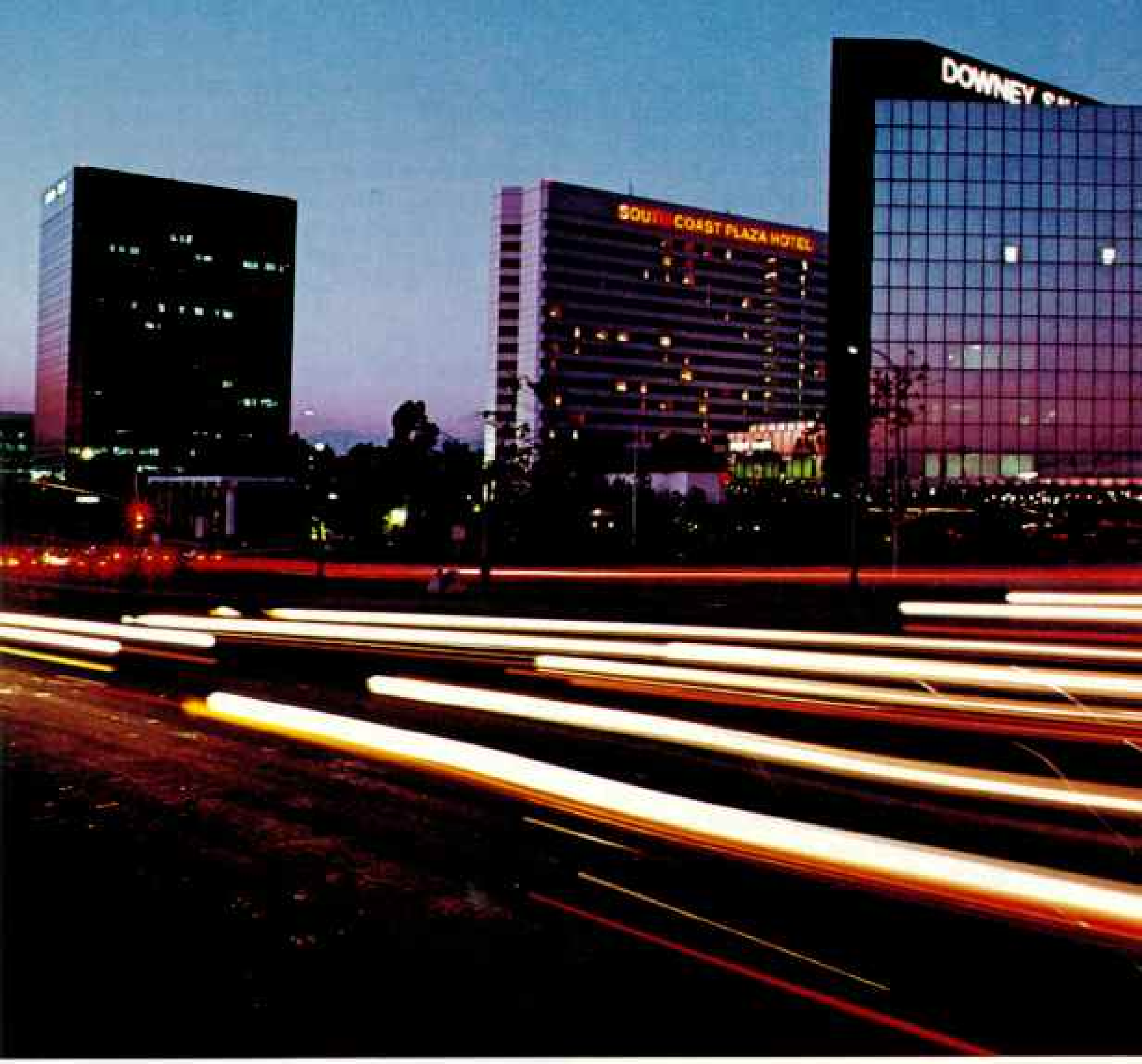
For weeks we merged into the frenetic flow of vehicles on freeways that arc over towns and sere ranchland. We strolled the sands of Laguna Beach and visited artists in cozy canyonside bungalows that climb from the sea. We sailed from Newport Harbor past imposing rows of yachts and south to Dana Point, which Richard Henry Dana described as "refreshing as a great rock in a weary land." We watched the steady beat of rocker pumps at Huntington Beach, where oil derricks, both on- and offshore, boost energy supplies.

In Laguna Hills we visited residents of Leisure World, which lies behind 8.5 miles of six-foot-high walls and sentry posts. It was just selling the last of its retirement homes for $350,000 and up. The youngest of its 21,000 residents, by mandate, is 52; the oldest, by chance and good health, is 103. Delivery "boys" for the weekly newspaper are in their 70s. Children are welcome—as visitors. Shopping centers around Leisure World, like many in the county, are thick with financial institutions and travel agencies.

The opulence of Leisure World reflects the wealth of Orange County. Median family income is close to $30,000, high even in California. Retailers hasten in from across the land: Neiman-Marcus opened its first southern California store not in Beverly Hills but in Newport Beach. Last year Roy Carver's automobile agency there sold more Rolls-Royces than any outside London. Henry Segerstrom, a one-time lima bean farmer who refused to sell out to developers, himself developed the family land into South Coast Plaza, one of the world's most profitable shopping centers. He presents office visitors with burlap sacks of beans from adjacent acres. He is also donating 11



World's favorite mouse *brought fame to Anaheim when the city helped Walt Disney put together a 300-acre site for his pioneering Disneyland park, opened in 1955. Here in January 1981 Mickey welcomes the 200 millionth visitor.*


DOWNEY
COAST PLAZA HOTEL

Silhouettes of success *range from backyard oil pumps in Huntington Beach* (**left**) *to the glitter of the South Coast Plaza complex along Bristol Street* (**above**) *in Costa Mesa.*

Santa Ana-born J. Robert Fluor (**right**) *heads the corporation that engineered a billion-dollar petrochemical plant in Saudi Arabia and pumping stations on the Alaska pipeline. He moved Fluor headquarters from East Los Angeles to Irvine after surveying employees, who opted for "the bright and new and appealing."*

million dollars in land and cash toward construction of a performing arts center meant to equal Los Angeles' Music Center.

But no one in wealthy Orange County has yet found a way to buy off the natural forces that plague it. All over southern California, erratic Santa Ana winds, which probably take their name from Santa Ana Canyon, bring hot, dry days and fire warnings.

One November afternoon near El Toro, the Santa Ana was gusting to 60 miles an hour, shaking the orange trees as well as eucalyptus trees planted as windbreaks. In the mountains to the northeast, hundreds of fire fighters were seeking to save canyon communities from a 28,000-acre brush fire fanned by the searing winds. We drove through blackened land to a trailer home that had escaped the conflagration and met Ray Serrano, 80. He'd spent all day fighting flames nearby in what he called the Indian way: flapping wet gunny sacks on hot spots.

"I worked as a cowboy on the Irvine Ranch until I was 66," he said as his wife served cold beer and homemade *jalapeño* jam on crackers. "It used to be two dollars a day and board and bunkhouse, and it was

good," he said. "When I quit, I came up here so I could keep my own 20 head of cattle. But this land is being developed now. I got to move on. Maybe I'll go to Mexico."

The Irvine Ranch was shaped after the Civil War by a gruff entrepreneur, James Irvine, who merged three early land grants into an agricultural cornucopia that lay almost unchanged until 1950. A few years later Walt Disney arrived. About the same time, the Santa Ana Freeway was completed from Los Angeles to Santa Ana, a quiet county seat. Suddenly it was within 40-minute commuting range of swollen Los Angeles.

In 1950 Orange County was primarily rural. By the 1960s the new Santa Ana-Anaheim-Garden Grove metropolitan area was the second fastest growing in the nation, behind Las Vegas, Nevada. The surge was so disruptive that communities incorporated for protection. Dairymen established the town of Dairyland to keep developers out, cows and chickens inside, and taxes down. (Dairyland joined the urban rush in 1965, changing its name to La Palma; today it has nearly 16,000 residents and no dairies.)

As the county began to be bisected by more freeways, these bedroom cities of the

***Newcomers** in a land of immigrants, some 67,000 Indo-Chinese refugees, mostly Vietnamese, contribute to the county's changing face. Only Los Angeles County holds more Asian refugees in the United States. A new market **(left)** in a Vietnamese shopping center in Westminster takes its yellow and red colors from the flag of fallen South Vietnam, whose former premier, Nguyen Cao Ky **(above)**, lives in nearby Huntington Beach. But poverty daunts many refugees, often resented by Anglos and the largest minority, Hispanics.*

Goldfish in a straitjacket *serves as a useful subject for studies of how the retina connects to the brain. Dr. Ronald L. Meyer conducts this research at the University of California's Irvine campus, opened in 1965 and now serving 10,000 students.*

At American Edwards Laboratories, workers mount pig heart valves on frames for human heart valve replacement. Other medical devices made here depend on sophisticated computers, typical of Orange County manufacturing that helps generate 40,000 new jobs a year.

north were joined by an exodus of business and industry from Los Angeles, spurred by white flight and low labor unionization. The county also lured major sports franchises. The former Los Angeles Angels of the American League were reborn as the California Angels of Anaheim; the Los Angeles Rams of the National Football League also moved to Anaheim Stadium. Baseball's veteran Buzzie Bavasi, executive vice president of the Angels, told us: "This is simply the hungriest sports market around."

Land was the key to growth. Perhaps nowhere else in America does so much open land lie in the pincers of comparable population growth. Don Koll, 48, a Californian who has helped turn part of the ranchland into city, strode with us through lushly landscaped business communities he has built near John Wayne Airport.

Koll, who builds more than 100 million dollars a year in commercial property in western states, explained his zeal for Orange County: "It's like you had built all of Los Angeles," he told us, "and saved the best like Beverly Hills for the last. Los Angeles is full. To build there, you have to tear down. Here there is flat, empty land, and people lining up to buy half-million-dollar houses."

For Koll, who moved with his family to Newport Beach in 1958, the evolution of Orange County seems almost graphed: "Until 1960 the businessman's uniform around here was blue denims, Hawaiian shirt, and Top-Siders. Then a few real estate brokers in dark suits and black wing tips were sent down from Los Angeles to open offices. They thought they were going to be martyrs, but they invested in land and made fortunes. That's when outsiders began to take us seriously and moved in—particularly young people. It's a young population of doers. It's what the people of southern California used to think of as southern California before it got like everyplace else."

Ranch Spawns Building Boom

Vaster fortunes by far are being made in land than were made in the California gold rush. The 77,000-acre Irvine Ranch, sold in 1977 for 337.4 million dollars to a private consortium that includes Henry Ford II, sells about 700 acres each year but still owns one-sixth of the county.

On the original ranch have risen a 1,500-acre University of California campus, ten shopping centers, three golf courses, eleven apartment communities, six marinas, business centers, portions of several towns, and the new city of Irvine, incorporated in 1971. A gulch that was about to become a county dump has been transformed into the

grandiose Big Canyon Country Club; even with memberships going for as much as $80,000, there is a long waiting list. The ranch's remaining 3.5-mile shoreline was sold to the state as parkland. About 3,300 acres of orange groves remain, and 7,000 acres planted in row crops and avocados. Nearly 70,000 acres are still undeveloped.

The fantasies of Disney seem to have escaped beyond the gates of Disneyland. On Irvine acres, ranches look like planned communities, and new communities like Mediterranean villages. Churches may stand alone in cattle pasture because they were master-planned to be there. Some look like corporate showplaces, with mirrored glass skins, acute angles, rounded corners. Neighborhoods grow around them.

The University of California's campus on the Irvine Ranch opened in 1965 as the jewel of the master plan. Its grounds are surrounded by tawny rangeland. Set almost out of sight from major thoroughfares, it faces problems of community linkage. Its distinguished academicians, like physicist Frederick Reines, a co-discoverer of the neutrino who received the Oppenheimer Award in 1981, are better known in other parts of the nation than in Orange County. "If we were the leading business forecasting center of the West Coast, they'd all know about that," the university's executive vice-chancellor, James L. McGaugh, told us.

The university and the land-oriented Irvine Company grope for common bonds. Some thought the new city of Irvine might form such a bond. Attorney Dennis Carpenter, former state senate minority leader,

Before the crowds roll in, *Newport Beach offers a quiet morning roost to artist-designer Ron Henderson and his macaw, Macky. A Los Angeles native, Henderson painted 12 years in Europe before his 1979 move to Orange County, whose changes he applauds. "This is where the promise is," he says. "And the beach."*

told us: "Irvine didn't exist as a city in 1970. Now it's the second biggest in area in the county. The Irvine Company created the city that has become a monster lashing them regularly on growth-control issues." Like any new city with sophisticated planning, Irvine has become its own place; its leaders resent outside interference.

Near El Toro, home base for most West Coast U. S. Marine Corps aviation units, we found the ranch headquarters of the Irvine Company. Old frame ranch buildings were sheltered by stately eucalyptus windbreaks. At the general manager's desk, Fred Keller, a smiling, open-collared farmer, told us he had no illusions that agriculture is more than a holding action on this costly acreage.

"We have sort of strange problems," he said. "Local sound ordinances, in effect from 8 p.m. to 7 a.m., mean less noise in decibels than our talking here right now. Normal farm operations are curtailed at night. We take unusual care with pesticides. But when people in these new towns all around us get sore throats, they'll call me up and say, 'You been spraying?' "

Four cowboys oversee about 3,500 cattle that serve as lawn mowers for close to 50,000 rolling acres still in rangeland. We left Keller's ranch office with livestock manager Bob Elder in his truck, his horse in the back. During a long wait at a red light to cross busy Coast Highway, Elder grinned.

"I've got to drive six miles through this kind of traffic to where I can mount my horse and get movin'!" he said.

County Welcomes Rocketing Industry

Much of that traffic is related to the avalanche of industry into Orange County. Aerospace and electronics dominate, with facilities of Hughes, McDonnell-Douglas, Rockwell International, Beckman Instruments, and others. John Wayne Airport is a jungle of private aircraft and home of Air California. Despite stringent curfews, the airport ranks as the fourth busiest in the nation in total takeoffs and landings, after Chicago's O'Hare, Long Beach, California, and Atlanta International.

Besides the aerospace industry, high-technology companies in computers and pharmaceuticals have found a home in the county. For all of them, relatively low labor unionization is a lure—about half the rate of California statewide.

Some industries are exotic. One night at American Edwards Laboratories, in the midst of a seven-mile-long financial and industrial corridor, we watched workers unload cases of iced pig hearts flown that day from U. S. slaughterhouses to Los Angeles Airport. A waiting assembly line quickly sorted them by the quality of their heart valves, removed the valves, and cleaned and sterilized them for implantation into human patients across America (page 762).

In a mirrored-glass headquarters rising like a space castle from green slopes, we visited J. Robert Fluor, chairman of a six-billion-dollar firm bearing his name (page 759). Fluor employs about 35,000 people and builds energy facilities from Kuwait to South Africa and the Alaskan North Slope. Before moving his base from Los Angeles, Fluor polled his employees: 60 percent already lived in Orange County and commuted. Because traffic within the county ranks with expensive housing as a threat to future growth, Fluor tries to counteract both problems by operating van fleets that shuttle employees to and from homes as distant as 90 miles.

Soft-spoken and religious, Bob Fluor is a major force in the Republican Party. But he and others told us the county's conservatism has been diluted in recent years by a surge of in-migration.

"People in the East don't really understand California politics very well," Fluor said as we sat in his lofty executive suite. "They've read about Orange County and its presumed arch-conservatism, but we have a pretty even political party registration. Still, California seems three times as far from New York as New York seems from California. If you travel, you soon see all the nuts are not out here, I can guarantee!"

His appraisal of the county's political balance was echoed by James McGaugh on the University of California's Irvine campus. "When we moved here, my wife and I were almost the only two Democratic voters in our precinct," he said. "Now the ballot stacks are about even. Orange County is a very comfortable place to live. This is a buzzing, booming place of broad-gauge pragmatists. Right-wing extremism has become a nonissue."

Awaiting the starting gun, *700 sailboats maneuver off Newport Beach before the annual 125-mile race to Ensenada, Mexico. One of the world's largest*

concentrations of pleasure craft—9,000—crowds Newport's harbor. Some of their owners shop for million-dollar waterfront homes as the surest route to docking space.

The strength of the extremists has become diluted by the growth of technology and educational facilities, a procession of transplanted corporate headquarters teams, and the county's 286,000 Hispanics, 87,000 Asians (many Vietnamese and Cambodians), and about 25,000 blacks. The student body of the Irvine university is about one-fourth Asian, black, and Hispanic.

East of the university in the "golden triangle" of a freeway junction, where strawberries were being picked on the day we visited, the Irvine Company plans to build a 480-acre center. It will include eight department stores, 200 mall shops, four million square feet of office space, and three hotels.

"People keep telling us there's no real focal point in Orange County," Peter Kremer, Irvine's 41-year-old president, told us. "We're building one."

Worshiping in a Glass House

But that lack is not what some residents mean when they talk of the shallowness of life in instant communities, or in crowded, older ones. Churches try to fill the voids. Some Orange County residents find solace within the imposing 16-million-dollar Crystal Cathedral in Garden Grove (pages 754-5), where we worshiped on a December Sunday when 5,000 poinsettias brightened 10,660 panes of mirrored glass. Choreographed fountains dazzled the smiling congregation as a procession of bell ringers moved down the aisle and the Reverend Robert H. Schuller produced his televised "Hour of Power," beamed through the United States, Canada, and Australia with an annual budget of more than 24 million dollars.

As the service began, two 90-foot glass walls swung silently open so that the minister could be seen by drive-in worshipers from their cars. He calls his church a "service center for God," and his enterprises are so diverse that the church has 42 listings in the telephone directory.

Looking about at the congregation, we marveled at the cheery faces. Many people of Orange County seem fresh and uncommitted, prone to quick fixes of body and spirit, enchanted with their place and time, fancying their particular labors, and absorbed in the search for comfort, wealth, leisure, and hope. Most are not disadvantaged. That morning the minister invoked the name of John Wayne, an Orange County resident for years, as a symbol of good.

Later we drove through the shaded streets of older Santa Ana to Our Lady of Guadalupe Church on Central Avenue, where, each Sunday, four Masses are conducted in Spanish, one in English. Families lingered after Mass as if awaiting a traditional plaza promenade in Guadalajara, the women in lace mantillas, the men standing apart.

One night we talked to Mexicans in an amiable queue outside Santa Ana's tiny Western Union office. Many workers send a

Mouth-watering specialties, *from avocados to strawberries* ***(above)****, flourish in one of the state's more productive farm counties. Yet agriculture is considered by many only a holding operation until development comes. Irvine Company cowboys* ***(facing page)*** *move Brangus and Braford across pastures near homes of Laguna Hills.*

share of their wages via telegraph to families in Mexico. Several grinned when we asked why they didn't mail it.

"In Mexico," one said, "it is no good to send money through the mails. Always the telegraph."

As of the 1980 census, Hispanics are the largest segment of Santa Ana's population.* But Hispanics have not achieved a proportionate influence in local government. Social services and schooling sag. Santa Ana still has an all-white school board, and politicians fret over the millions billed for medical care of indigent aliens. (The Hispanic community is fed by overnight bootleg shuttles from the Mexican border, bringing in illegal aliens at $300 each.)

"Neither local government nor industry has faced up to its responsibility," Father Allan Figueroa Deck told us. He is the former pastor of Our Lady of Guadalupe parish church, and now director of the Roman Catholic mission to county Hispanics. He concedes that Mexicans earn in one day here what they earn in a week in their native land, and that their labor is essential to economic growth.

"But their sacrifice is culture shock. Their social life, their family patterns, their traditions collapse here. You cannot encourage or allow people to come, whether legally or

*Griffin Smith, Jr., looked at the Mexican Americans' swelling numbers and growing ethnic awareness in the June 1980 GEOGRAPHIC.

Striking poses for art's sake, *volunteers portray Nicolas de Largillière's "Louis XIV and His Heirs" during Laguna Beach's 50-year-old Festival of Arts. For the Pageant of the Masters, some 40 works come to life, accompanied by narration and orchestra music.*

illegally, and keep shoving them on top of each other."

Refugees Face Uphill Battle

The county has also had the largest influx in the nation of Asian war refugees, mainly because many were processed at the U. S. Marine Corps' nearby Camp Pendleton.

Their plight may be direr. As they cluster in apartments in predominantly white towns like Garden Grove, tensions grow. Few speak English; cultural trauma and depression are common. There is bitter competition with other minorities for limited jobs, housing, and welfare aid.

The first wave of Vietnamese in 1975 spoke some English and had been able to bring out some possessions. Among them was Nguyen Cao Ky (page 761), the former South Vietnamese premier, who lives in a Spanish-style house in Huntington Beach and operates a liquor store nearby. "Later arrivals," Ky said, "seem to have it harder."

Mrs. Jessie Thacker, principal of Cook Elementary School in Garden Grove, where as many as half of the pupils are Vietnamese, studies their language by night. Texas born, she is among many who seek to ease the newcomers' path.

"First we had to explain to parents and pupils that it was not a matter of whether we *would* take them," she told us, "but how we could best educate them. None of us knew much of their culture. We searched for interpreters—I have three now—but my refugee funds have expired, and the children speak little or no English when they enroll. They need three years to learn."

Another who strives is Nguyen Nhu To-Oanh, a woman of 21 whose voice is as gentle as a wind chime. Oanh (pronounced Wan) left Vietnam for refugee camps in 1975. She works at the refugee center at St. Anselm's Episcopal Church in Garden Grove, helping with daily classes in English for 300 Asians from 17 to 57.

"Our people have opened restaurants, food stores, and other shops," she told us. We saw their signs and banners along Bolsa and Westminster Avenues.

Do her people expect to return home someday?

"I think the new ones do," she said. "Just as I used to think I would. Now we are working. We know there is little chance, little hope really to go back. And it would not be the same."

And her own dreams?

"I did not allow myself to think about dreams for a while," she said, "but someday I hope to go to California State at Fullerton.

Maybe I will become a fashion designer. That is my American dream."

The campus that is Oanh's goal is the larger of the two four-year universities in Orange County, with 26,000 students. Its program for disabled students has drawn 1,000 persons.

"It was relatively easy for us to meet federal standards for such a program," Paul K. Miller, director of Handicapped Students Services, said. "Our campus is on flat ground. Like so much else around here, it used to be an orange grove. Our walkways are flat, and our elevator-equipped buildings are close together—easier for students moving between classes with crutches, wheelchairs, and Seeing Eye dogs."

Another skillfully adapted plot of land has become Roger's Gardens, across from Newport Center, a showplace shopping-office center that houses the Irvine Company headquarters. A dazzling retail nursery, it ranks as a regional botanical shrine. Its clientele is made up not of farmers but of the owners of sprawling new estates behind guarded walls, some selling for five million dollars and more.

The best addresses are in and around Newport Beach and its harbor islands. Those who claim status in Orange County tend to descend not from Spanish grandees but from old-line Angelenos, to whom all Orange County ever meant was a weekend house at Newport Beach and perhaps a back-yard dock. These sheltered waters offer many of the charms and challenges of the Atlantic coast, but they offer them around the year.

Yachting and surfing are no longer mere avocations; they have spawned industries of research and design. Orange County's Hobie Alter, 47, who was a pioneer of custom-made balsa, fiberglass, and foam surfboards in the 1950s, built the speedy twin-hulled Hobie Cat, one of America's most popular weekend sailboats. Surfboard shapers introduced the notion that surfers require different boards for different surfs. Custom-made boards sell for $300; serious surfers may own ten. At Dana Hills High School, as at others along this coast, surfing is taught for credit in lieu of gym classes. Pupils convene on the beach in wet suits at 6 a.m. The talk on campus is of new variations in fast and maneuverable twin- and triple-fin boards.

End of an Era—Punk Debunked

The proximity of schools and beach is part of growing up in Orange County. Fads in music, dress, sports, and slang flow back and forth. Punk-rock bands, formed in the 1970s by bored, out-of-work British youths, soon appeared in Hollywood, then Huntington Beach and Costa Mesa. Cases of violence followed. Punkers with close-cropped hair, dyed gaudy colors as part of a defiant image, slashed out at society and each other with broken bottles or knives. But both punks and police agree the cult has ebbed. "Orange County is too wealthy to spawn real dedicated punks," complained a Los Angeles punk musician.

"That era is passing," said Steve Rogers, 28, a surfer and lifeguard at Huntington State Beach. "When a fight breaks out on the beach, it's usually because the surf's down and it's crowded. Surfers have a territorial attitude about a beach. There are a lot of standoffs and stare-downs between old-timers and newcomers, but there isn't violence in the air. I walk the beach every day and see punk hairstyles, mostly on teenagers. But surfing is still a clean sport out here."

It was Angelenos driving down to Newport Beach who helped a farmer named Walter Knott survive the Depression. Now 92, he began selling berries from a roadside stand on ten rented acres in 1920. His wife added homemade jams and pies and began cooking chicken dinners for passing motorists. Their daughter, Virginia Knott, recruited as a waitress from the first night,

***Catch of the day**—rockfish—lands a smile from Jay Brewer, 17, youngest fisherman in the 12-man Dory Fleet whose morning hauls have gone on sale beside Newport Beach pier since 1891. Camaraderie links the fleet, but each man works alone, putting out in a pointed-bow dory to pull lines set the previous day. At 15 Jay built his boat to join the life he considers "best in the world."*

Escape to mountains and sea: *The California promise of individual freedom materializes on a checkerboard of year-round playgrounds. Windsurfing* ***(below)****, a cross between the perennial California favorites of surfing and sailing, is popular in protected harbors along the Orange County coast.*

In the rugged foothills of the Santa Ana Mountains ***(right)****, those with mechanical bravado live out their fantasies at Saddleback Park. On 700 acres leased from the Irvine Company, land-scarring trails attract dirt bikes and other off-road vehicles. In the distance Irvine Lake, stocked by the company, offers trout, bass, and bluegills. Such recreation is important both to residents and the 750-million-dollar-a-year tourist industry.*

remembers that they served eight dinners at their living-room table and used their wedding china.

Knott, who became a kingmaker among political conservatives, built Knott's Berry Farm, a homey 150-acre spread that draws 5.5 million visitors a year to its rides, entertainments, restaurants, and shops. It ranks third in attendance, after the Disney parks, among U. S. theme parks. It and Disneyland have helped to make the Anaheim Convention Center one of the seven largest in the country.

"But we're still farm people," Virginia Knott told us. "It's been a family partnership through three generations. We were frightened out of our wits when we heard Disney was coming. But Walt told my dad there would be plenty for us all, and there certainly has been."

Taking Pride in Swimmers and Floaters

Unlike the Anaheim area, near Los Angeles, the southern third of Orange County has been slow to grow—until recently. Mission Viejo, with about 55,000 people, shows the civic pride of a newly established community in its Olympic swimming medalists. Its near monopoly in recent years of the sweepstakes award in the Tournament of Roses Parade at Pasadena is the fruit of intense civic endeavor. Instead of hiring professional float decorators, developer Philip Reilly has enlisted citizens to go to Pasadena by the busload and help build their prizewinners. "Somehow," says Gavin Herbert, president of Allergan Pharmaceuticals, "Phil has kept Mission Viejo from being just a bunch of subdivisions. It has a hometown atmosphere."

The Spanish influence reflected in its name has been felt in this area since 1769, when the Franciscan missionary Father Junípero Serra marched up from Mexico to begin building the chain of California missions. A replica of his church at San Juan Capistrano is being built near the ruins of the original, tumbled by earthquake in 1812. Pageantry surrounding the return of the swallows to this mission each March perpetuates venerable Spanish folklore. The oranges that still grow in the county are Valencias, their stock brought from Spain.

Rancher Richard J. O'Neill, who sold the site for Mission Viejo to Philip Morris Incorporated, showed us an aerial photograph of the property taken in 1964. It was houseless, like most of the magnificent acres O'Neill retains east of San Juan Capistrano.

Stout and tousled, O'Neill combines engaging warmth with stubborn determination to remain an Orange County and Old West original. He and his sister inherited a sizable remnant of the vast Rancho Santa Margarita, bought in 1882 by their grandfather and James Flood. Flood had parlayed his Comstock Lode into a banking fortune and a Nob Hill mansion that is today San Francisco's Pacific Union Club.

Before World War II the ranch was 250,000 acres. Then the government bought 180,000 acres for Camp Pendleton Marine Corps Base. Its rugged, scruffy hills and circling helicopters seem to stand ready for filming of an opening scene of TV's "M*A*S*H."

"Of course, the Irvine Ranch is larger. We're the Avis of Orange County," Mr. O'Neill said, grinning as he swabbed a thick slab of beef with hot sauce in his ranch kitchen. He swallowed it happily. "When the government bought Pendleton, there went our 17 miles of shoreline. All we have left is 42,000 acres. Our main game is taking the land from agriculture into the 21st century. The way Orange County is going, that's about 25 years' worth of land." He peeled a banana and it disappeared in a flash.

That afternoon as cloud shadows scudded across his green valleys and gray hillsides, past wild holly and gnarled live oaks, he drove us to his Thoroughbred ranch, walked us through the Cow Camp that has served vaqueros as a site for roundup and

Sold out *before the rafters rose, a new neighborhood of $160,000 homes takes shape in Mission Viejo. The planned community, begun in 1965, today boasts 55,000 inhabitants. But home ownership increasingly eludes middle-income families in Orange County. It now requires developers of unincorporated areas like Mission Viejo to build 25 percent of their units within the price reach of families whose earnings fall around the $30,000 county median income.*

branding since 1882, and confided that he was about to retire after his two-year term as state Democratic Party chairman.

"In Orange County we Democrats outregistered the Republicans a few years back," he said, "for about 15 minutes. No matter. Nearly half register Democrat, but they mostly vote Republican."

Great View, Gloomy Observation

The county's best known Republican, Richard Nixon, was born in the Quaker town of Yorba Linda in the north, and retreated from Watergate and the White House to live for a time at San Clemente in Casa Pacifica, the sea-cliff estate that had served him as western White House. In 1979 pharmaceuticals magnate Gavin Herbert and his wife, Dorraine, bought the house.

On a Saturday afternoon we strolled with their children and pets through acres of gardens. It is a happier place than in the past. The undergrowth that shielded Richard Nixon from curious beachcombers has been cut back to give a majestic sea vista.

In gazebos where Secret Service sharpshooters watched, there were board games and books and the easel of daughter Pam Herbert, an art student at the University of Southern California. She also sprays old tennis balls black and, using a Civil War cannon from the Metro-Goldwyn-Mayer back lot, gleefully fires harmless volleys among the surfers offshore.

Upstairs in the study where Nixon spent soul-searching hours, the new owner settled into an easy chair and sat staring at the sea. He is one of many who have made fortunes from scratch in Orange County; when Allergan was sold to the giant SmithKline Corporation in 1979, he became SmithKline's largest stockholder. He did not appear to have nagging worries.

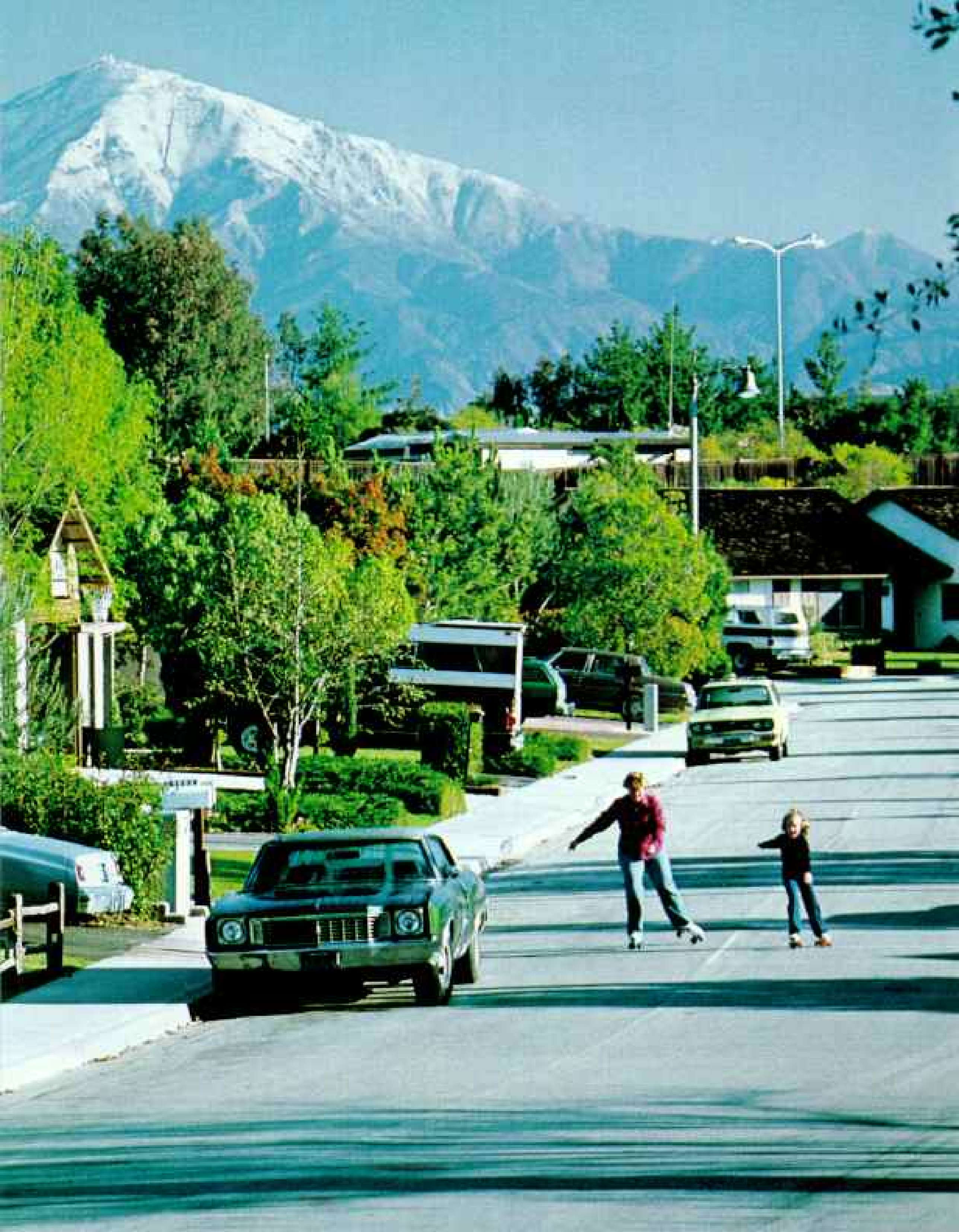
But, we learned, he has concerns, not unlike those that had haunted us as we roamed this bustling county.

"What do you like best about Orange County?" we asked.

He never looked away from the gleaming sea as he answered.

"The openness," he said softly. "The orange trees. The feeling that there is room for everybody. The quiet. All the things we like best are disappearing." □

Early-bird *roller skaters in Mission Viejo catch a rare glimpse of snow on the county's highest elevation, Santiago*



Peak, called Old Saddleback. Open land will soon be as precious as snow in Orange County if development keeps pace with demand. And so the dilemma: how to satisfy that demand without destroying the virtues that created it.

THE OCEAN

A Perspective: JACQUES-YVES COUSTEAU

A ten-foot wave flings its energy on Waimea beach, Oahu. BRYAN JACKLIN

H_2O *Two atoms of hydrogen and one of oxygen. Water. The commonest, most abundant substance on the face of the earth, yet how rare this liquid is in the rest of the solar system and perhaps even in the galaxy.*

Why should earth alone have been so lavishly gifted with this most precious of natural resources? Only minute traces of water in the liquid state have been found anywhere within reach of our telescopes or space probes.

The waves thudding on a distant shore are the heartbeat of

man's ancestral home. The salt solution of the sea flows in man's veins, and—is it coincidence or part of nature's master plan?—70 percent of man's body is water, the same proportion as the surface of the earth.

The great question today is: Can the sea help mankind survive? What is more, can it help man not only survive but also lead a full and rewarding life; in other words, live rather than exist?

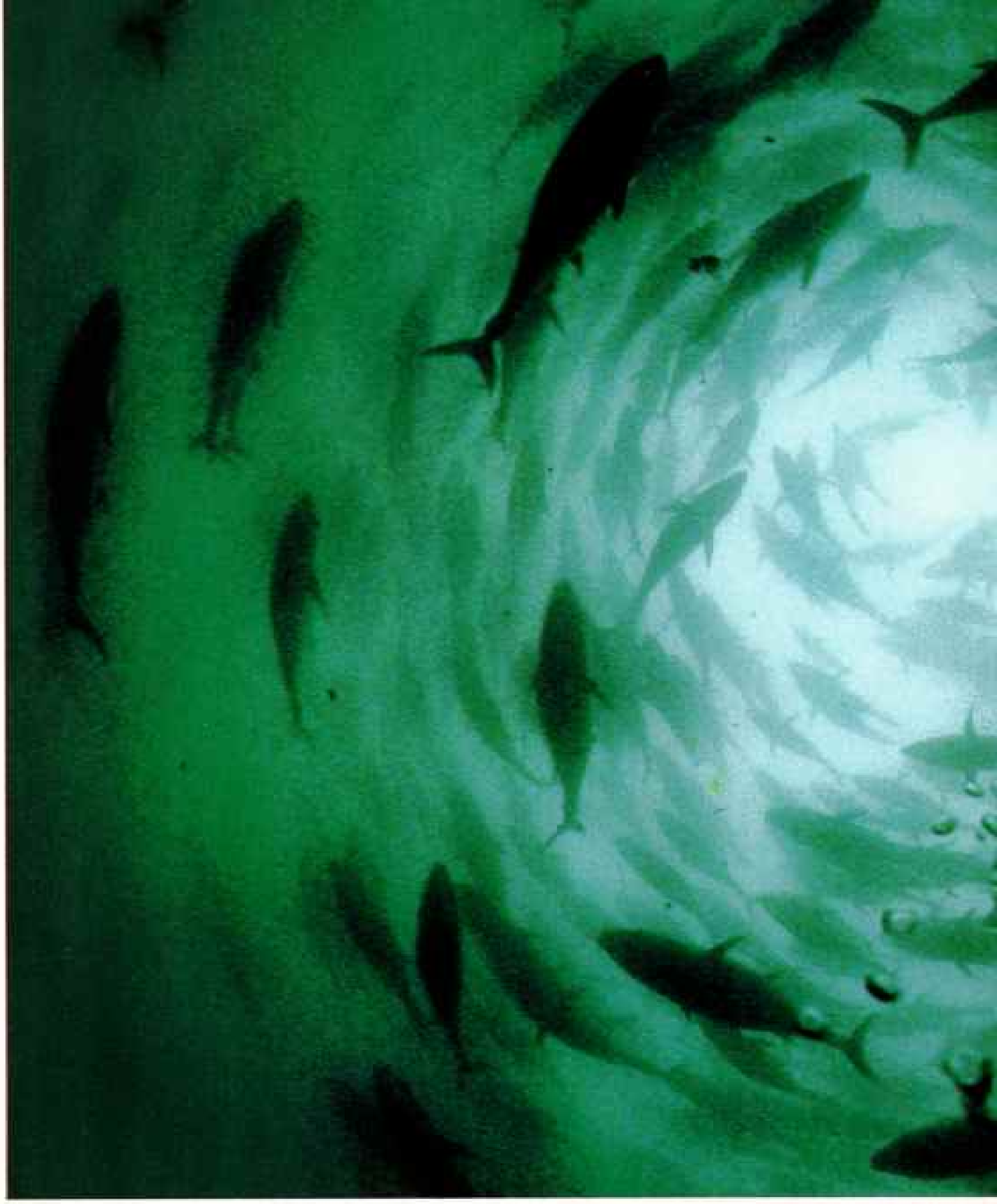
I believe it can do both, in our quest for life's essentials. Since seawater covers so much of earth's surface, it is natural to look to

Clots of molten magma fly at the birth of a new South Pacific island in the Solomons. WALLY MUELLER

the sea for our food, our energy, and, ultimately, our minerals.

These questions grow more pressing as the world's population continues to explode. Although some scientific estimates show that the planet can support in relative comfort only one to two billion people, there are already on earth more than double that many, and the United Nations predicts that by the year 2100 the swarms will reach the staggering figure of 11 billion.

The basic problem is formidable: While the world population continues to grow, the earth remains finite.



John Stuart Mill, in the relative abundance of the Victorian age, wrote that man had to learn to bring his numbers into rational adjustment with the earth's bounty. That, and that alone, is the ultimate solution, but meanwhile the sea can help us.

In the more than half a century I have dedicated to the sea, I have had moments of despair, but fundamentally I remain an optimist. If I were not, I should pack my instruments, dock my vessel, and head inland.

All animals, including man, share the same basic motivations:

Young tuna circle in a floating ocean cage at a Japanese aquaculture laboratory. DAVID DOUBILET

territory, food, reproduction, competition among species. The key word to describe life is, therefore, unity. We are all part of the pyramid of life, and where the pyramid is broad based, as in benign climates, the future of life is secure. In places like Antarctica, where life is hard and there are great numbers of only a few species, the pyramid is fragile. Destroy a species and you place the whole structure at risk.

Because the sea is so vast, it resists man's onslaught. However, the overall vitality of the sea is decreasing. Is this because of

pollution or because of what I call mechanical aggressions? Both. Although people are now aware of pollution, few speak of the mechanical assaults, such as marsh draining and coastline altering, that may do much more harm.

The sea is so vast that when we try to study it by lowering an instrument, we are examining a macro-medium with a micro-tool. It tells us only what is happening at that moment at a single point in the ocean, but little about the sea in general.

I predict that oceanographic vessels will become rare and

Polar bears gorge on the carcass of a Greenland right whale. ELI C. NORDEN ANDERSEN

be used only for highly specialized studies. The future of oceanography lies in spreading over the sea hundreds, perhaps thousands, of drifting instrumented buoys. These will be interrogated continually by an array of satellites in space, and computers will integrate all the data to give an instant picture of what is happening on and in the ocean all over the world.

The first concern of any species is food. Yet even if all the potentially arable land on earth were cultivated, there still would not be enough food to feed man's multiplying billions adequately.

One thinks at once of fishing. But capturing animals from natural wildlife stock cannot take us very far; in fact, in many instances it has already gone beyond the sea's capacity to sustain the yield.

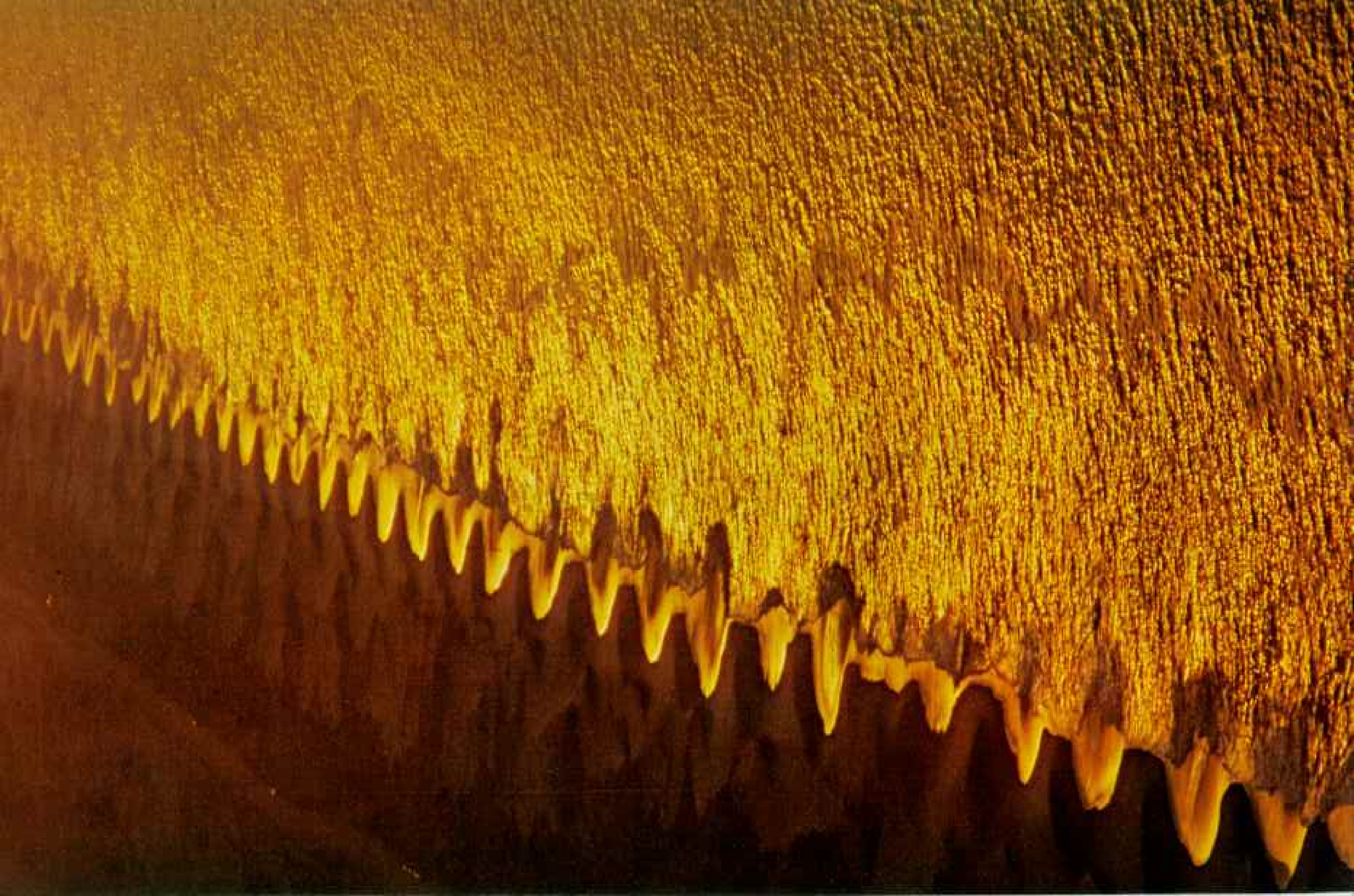
Ten years ago the Food and Agriculture Organization of the United Nations estimated that the world fishing harvest might be doubled to 100 million metric tons a year by encouraging the building of more vessels and use of advanced techniques by fishermen in developing countries. Tonnage has risen, though

Immobilized by Arctic pack ice, oil-exploration ships await summer thaw in the Beaufort Sea. LOWELL GEORGIA

unsteadily, to stabilize at about 70 million tons. It will never reach 100 million tons this way.

Aquaculture: This, too, to me is something of a blind alley. Fish farming of shrimp, flatfish, sea bass, salmon, all luxury foods, is far too expensive to sustain 11 billion people in 2100.

On land, most food animals are vegetarians. They eat grass or grain and turn it into flesh, at a ratio of one pound of flesh for each ten pounds of green matter. In the sea the disproportion is much greater. Ten tons of phytoplankton, minute plants, feed one



ton of zooplankton, microscopic floating animals. Ten tons of zooplankton will generate one ton of small fish; ten tons of small fish make one ton of big fish like tuna.

So the fish is not the animal to bring us protein in mass. No, we must short-cut the normal chain of protein production in the sea in order to achieve the ten to one ratio of land animals.

There are a number of land animals that are perfectly happy with a diet of algae. Giant kelp has been cultivated in open water off California. It grows two to three feet a day and makes excellent feed for goats, sheep, and other livestock.

Energy: People tend to forget that solar energy is the only renewable energy resource we have. Unfortunately, it is spread thinly over the surface of the earth, which makes its recovery difficult. Solar cells or furnaces would need to be deployed over enormous desert areas in order to match the output of a single nuclear power plant.

Luckily, we have in the ocean a natural concentrator of solar energy. Tropical currents constantly bring sun-warmed surface water to areas like the Straits of Florida and the Caribbean, concentrating formidable amounts of energy.

Two-thirds of all solar energy reaching the earth falls on the sea. One-third of that is reflected or degraded. Of the equivalent of 115 million nuclear plants, the total amount of solar energy striking earth, the equivalent of 20 million nuclear plants (20 million times a thousand megawatts) is absorbed by the tropical seas alone.

Pilot plants are already exploring ways of recovering this immense store of energy from the heat sink of the ocean. Pumping deep cold water to the surface of warm seas would enable us to exploit the temperature difference as power. And there are many ways of translating waves and tides into power.

Wind power, too, comes from the sea, since a principal source of wind is the temperature difference between sea and continent. Winds blowing constantly in the same direction, trade winds and the roaring forties, contain stupendous amounts of solar energy waiting to be harnessed.

Space exploration has brought us the most precious gift of all, a global consciousness. However fragmented the world, however intense the national rivalries, it is an inexorable fact that we become more interdependent every day. I believe that national sovereignties will shrink in the face of universal interdependence. The sea, the great unifier, is man's only hope. Now, as never before, the old phrase has a literal meaning: We are all in the same boat.

That boat is the spaceship earth, a blue jewel glowing in the night of space, radiant and shining with the fluid of life—the all-encompassing sea. □

Waves scallop a beach on the coast of Brazil. NICHOLAS DE VORE III

In 30 extraordinary years, scientists have opened the

NEW WORLD OF THE OCEAN

By SAMUEL W. MATTHEWS
SENIOR ASSISTANT EDITOR

THE WORLD OCEAN. It blankets seven-tenths of the earth, salt bitter, oft storm racked, most of it pitch dark and near freezing. Averaging two and a half miles deep the world around, it holds, by some estimates, 99 percent of the life-supporting space on our planet.

It separates the great landmasses of the globe, affects their weather, provides their life-sustaining rain, receives their off-flowing waters—and poisons. It surges to the pull of the moon and sun, swirls to the spin of the earth, and carries in its currents the energy of solar heat and the chill of polar ice.

I have lived beside the sea, sailed upon it by catboat and Navy cruiser, crossed the Atlantic, Pacific, and Indian Oceans, flown above the Arctic, and dived to the floor of the Caribbean Sea in a tiny submersible. Nonetheless I *know* almost nothing deep and certain about the ocean. Its essence is immensity, and mystery, and power.

So it is to most of us, even in this heyday of science. Man has lived by the ocean and voyaged upon it for thousands of years. Yet only in the past three decades, one human generation, have we begun to see, to map, and dimly to comprehend the true nature, shape, and complexity of the world ocean. It is a startling prospect indeed.

In 1950, only a few years after World War II, Rachel Carson published *The Sea Around Us*. She told of what science knew then about the ocean—its origins, currents, unseen depths, and strange life forms. But many a chapter of her evocative review ended on a similar note: "At present we do not know. . . . No one now can say. . . ."

By 1981 many of those blanks were being filled in. Instruments not even invented three decades ago now measure the vast movements and forces at work in the ocean. Undersea vehicles carry explorers thousands of feet deep to towering mountain ranges and yawning rift valleys. Satellite sensors and seismic stethoscopes take the pulse of earth itself.

Consider just a few of the things we now know about the ocean, after these 30 historic years of exploration:

• The seafloor—that nearly 72 percent of the planet's crust covered by salt water—has been "seen" with sound waves and mapped in fine detail for the first time. (Its mind-boggling features appear on the **World Ocean Floor** map with this issue.)

• The seabed is constantly being created and destroyed; the oceans are opening or closing; the continents around them are drifting, carried on giant rafts. New crust oozes up in molten form from below, solidifies, and moves outward; old, cold crust dives into deep trenches and is reabsorbed into the interior of the earth.*

• As the seafloor splits and moves apart, earthquakes jar the planet and volcanic mountains grow in the ocean. Minerals are born and deposited in the seabed: oil beneath deep sediments, metals from spewing hot springs, others from seawater itself.

• Ocean waters flow and overturn in unsuspected ways, carrying energy absorbed from the sun, regulating the earth's daily weather and long-term climate. They wash away—and ominously retain—man's most dangerous wastes. They nurture blooms of microscopic life, meadows of drifting plankton, entire fisheries.

• Life, which began in the sea, still reveals new and wondrous forms there, from bacteria flourishing in utterly dark depths to larvae of fish and crustaceans nourished in sun-blessed shallows, from myriad krill and anchovies to territorial sharks and intelligent porpoises and gentle, singing whales, largest of earth's creatures.

Man's driving curiosity about what lies in and under the oceans is nothing new, of course. We inherit it from our earliest human ancestors who ventured to catch and eat a fish, open an oyster, or drift out from shore upon a floating log.

*The author wrote about "This Changing Earth" in the January 1973 GEOGRAPHIC.

Seafarers sailed the Aegean at least 10,000 years ago, and had reached Australia by some sort of craft 10,000 years before that. Egypt's Queen Hatshepsut sent rope-trussed Nile ships down the Red Sea 3,500 years ago to the Land of Punt. Ancestors of the Polynesians voyaged in big canoes from somewhere in Southeast Asia far across the Pacific; Phoenicians may have circumnavigated Africa as early as 600 B.C.; Greeks and Romans, Arabs and Chinese roamed and pondered the limits of their seas.

Vikings who crossed the stormy, ice-strewn Atlantic all the way to the shores of North America a thousand years ago knew how to use ocean winds and currents. The fearsome, lava-spewing volcanoes they found in Iceland were peaks of the vast mid-ocean mountain range, now known to girdle the entire earth.

Though Arab dhows and Chinese junks were already trading around the rim of the Indian Ocean and the China seas, it was not for another five centuries that the first great age of ocean exploration opened in the West.

In the late 1400s Bartholomeu Dias and Vasco da Gama rounded Africa, Columbus rediscovered the Americas, and later Magellan proved that the oceans were not endless. The spirit of discovery led on to James Cook, in 1768 the first Western mariner to sail primarily for scientific knowledge; to Benjamin Franklin, who charted the Gulf Stream and who guessed that the continents move; to Charles Darwin, who circled the world on the *Beagle* from 1831 to 1836 and eventually realized that the different plants and animals he saw must have developed through natural selection.

While Darwin was at work upon his *Origin of Species*, a U. S. Navy officer named Matthew Fontaine Maury was pioneering the first organized, worldwide compilation of ocean winds and currents. He produced sailing charts based upon regular ship reports, thus becoming the founding father of international oceanographic science.

In 1855 Maury published *The Physical Geography of the Sea*. He began his chapter on the Atlantic: "The wonders of the sea are as marvelous as the glories of the heavens. . . . Could the waters of the Atlantic be drawn off so as to expose to view this great sea-gash . . . it would present a scene the most rugged, grand, and imposing. The very ribs of the solid earth, with the foundations of the sea, would be brought to light. . . ." He wrote of a broad shoal in mid-ocean: "a remarkable steppe, which is already known as the telegraphic plateau. A company is now engaged with the project of a submarine telegraph across the Atlantic." He spoke, had he but known it, of the vast Mid-Atlantic Ridge.

Seventeen years later Britain's John Murray and Charles Wyville Thomson went to sea on the historic voyage of H.M.S. *Challenger*. That first great expedition of marine scientists lasted four years and resulted in 50 volumes of reports, issued between 1890 and 1895.

Facts the *Challenger* collected are still in use—among them, water-temperature readings showing that a high mountain barrier must indeed divide the Atlantic Ocean basin down its middle.

World War I interrupted ocean exploration, though not such developments as the submarine and echo depth-sounder. In the 1920s and 1930s scientific voyages resumed, such as those of Germany's *Meteor*, trying to extract not only basic knowledge but also gold from seawater with which to pay war debts. And off Bermuda zoologist William Beebe and engineer Otis Barton descended in a steel ball on a cable, called a bathysphere, to view startling, headlight-carrying life forms half a mile down in the sea.

World War II opened the floodgates of discovery. In submarine warfare, in better ocean charts, in a multitude of developments from sonar to magnetic recorders, military needs led to new instruments and advances in marine hardware that would revolutionize what man knew of the ocean.

ROUND-FACED, somewhat roly-poly man lies on his stomach by a small view port inside a black, cigar-shaped craft slowly nosing on wheels through its own cone of light flooding the ocean floor. A portable hair dryer blows warm air across his neck, to prevent cramps and keep his breath from clouding the port.

He has been here many times before—a civilian oceanographer, though this is a U. S. Navy *(Continued on page 802)*

Sensing the ocean's crop by satellite

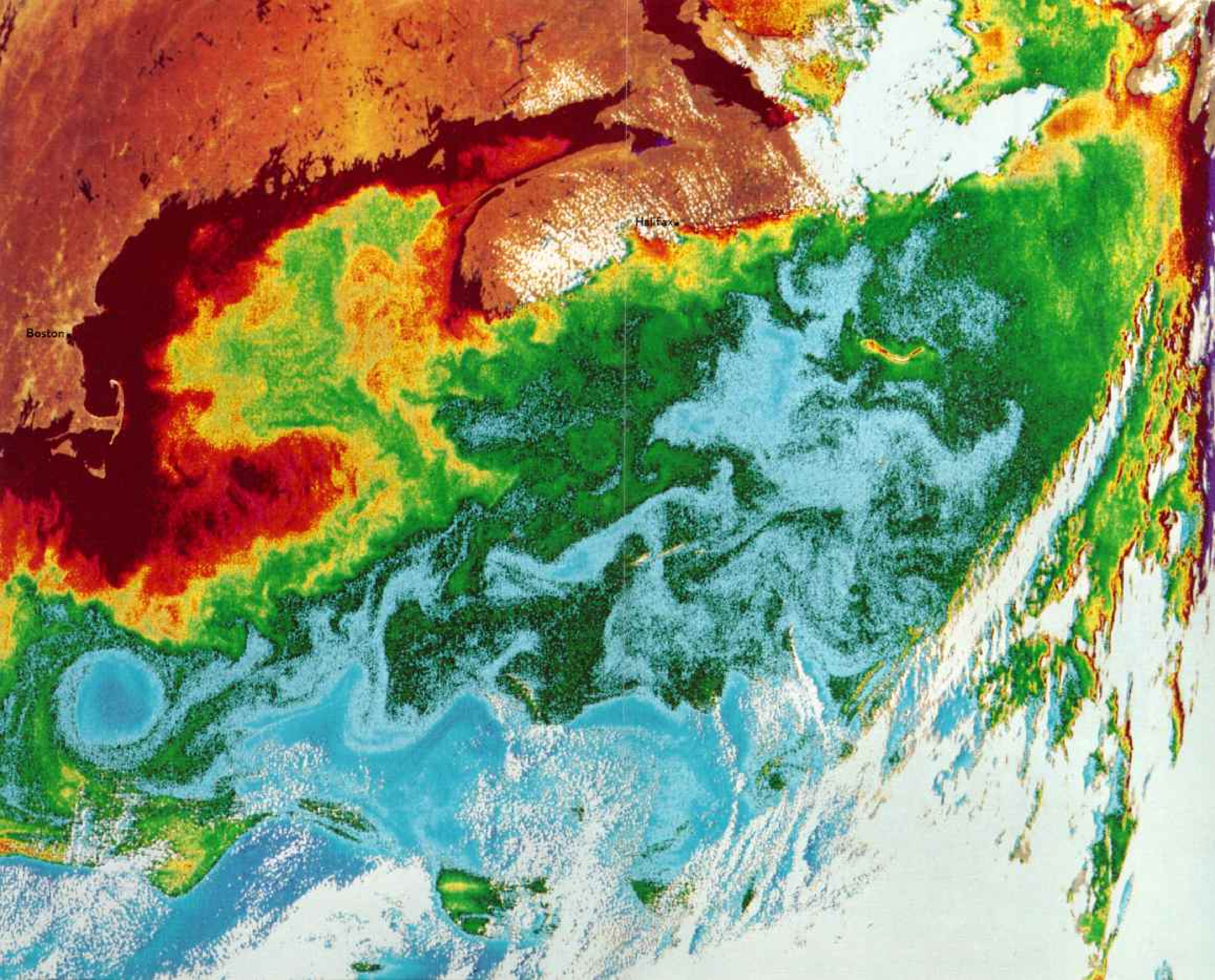
"WHERE ARE THEY BITING?" That familiar fisherman's question cannot yet be answered directly from space. However, the Coastal Zone Color Scanner (CZCS) aboard the Nimbus 7 satellite can answer this question: Where are the regions of greatest phytoplankton concentration? Where they are abundant, a fully developed food chain follows, including commercially valuable fish.

*A CZCS image of the Atlantic (**fold-out, right**), painted by a computer, shows concentrations of phytoplankton. The scanner detects absorption of certain wavelengths of light by the chlorophyll that plankton use for photosynthesis. The dark strip along the coast shows the most intense chlorophyll signal (white areas are clouds; land color is not significant). But it is frontal areas, where dark red changes to orange, that are most productive. One, east and south of Cape Cod, lies above Georges Bank, a shoal where winds and tides promote vertical mixing of water to sustain one of the world's most prolific fishing grounds.*

The nutrient-poor Gulf Stream is deep blue, with lighter blue segments breaking toward Nova Scotia. The nearly perfect blue circle is a warm core enclosed by a ring of colder water; south of it a yellow tail of more productive waters is being drawn offshore along the Gulf Stream boundary.

The CZCS is still experimental, and, in a time of budget cutting, its fate is uncertain. Yet it might prove as useful for the study of the sea as Landsat has been for continents and Tiros for weather forecasting.

NIMBUS 7 CZCS EXPERIMENT TEAM


Halifax
Boston

Journeys down into the alien deep

DARKNESS AND PRESSURE have been the major barriers to thorough undersea exploration. Although diving bells date back at least to the 16th century, it has only been in the 20th that the deep oceans have been seen from manned and remotely controlled vehicles. Even so, the ocean depths remain largely unexplored.

1 Glomar Challenger, *a 400-foot ship for deep-sea drilling, substantiated theories of ocean-floor formation and spreading.*

2 F.N.R.S.2, *buoyed by gasoline-filled tanks, made only one manned dive, to 84 feet. It descended unmanned to 4,554 feet in 1948, before suffering serious storm damage.*

3 Conshelf Three, *Jacques-Yves Cousteau's seafloor habitat, supported six men at 328 feet for 22 days in 1965.*

4 Submarines *in World War II had a depth limit of about 400 feet.*

5 Great white shark, *20 feet of appetite, cruises the upper few hundred feet of ocean.*

6 Techdiver *(PC-3B) carried two men to 600 feet. In 1966 it took part in the search for an H-bomb lost in the Mediterranean off Spain.*

7 Bluefin tuna *dive to 600 feet.*

8 Diving saucer *launched by Cousteau in 1959 operated to 1,350 feet with a two-man crew.*

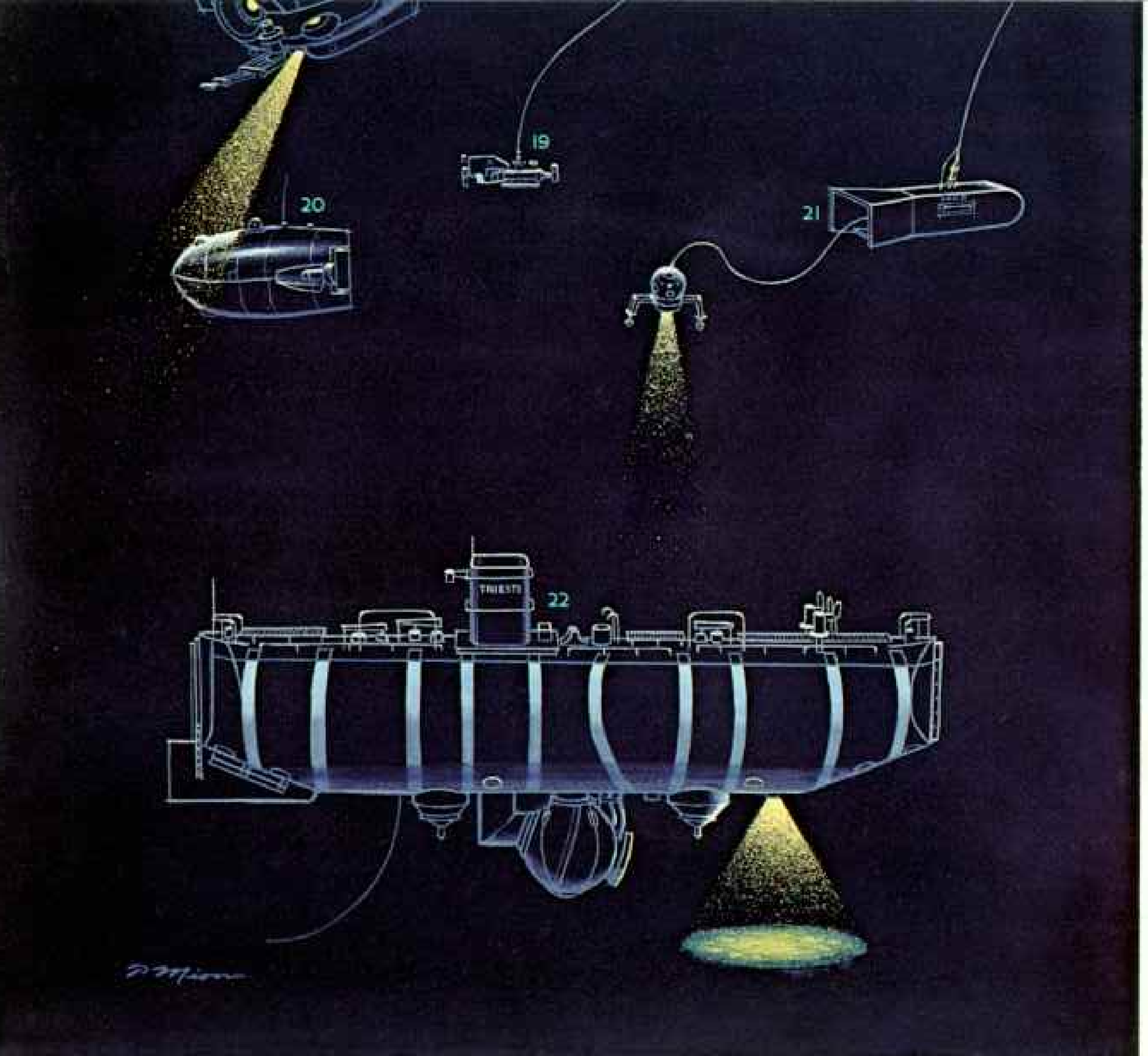
9 Jim suit, *controlled by the motions of its occupant, has exceeded 2,000 feet.*

10 Johnson-Sea-Link *operates with a crew of four to 2,000 feet. Divers can exit and enter at depth through a lockout hatch.*

11 Giant squid, *60 feet overall, may dive several thousand feet.*

12 Wasp-suit *occupant uses cable-supplied electric power to operate its manipulators down to 2,000 feet.*

13 NR-1, *a nuclear-powered U. S. Navy research sub launched in 1969, can operate to 2,300 feet and drive along the bottom on wheels.*



14 Bathysphere *only five feet across took two men to a record depth of 3,028 feet in 1934.*

15 Sperm whale *is known to dive to 3,720 feet but may go deeper.*

16 DSRV-1 *is one of two U. S. Navy vehicles designed to rescue crews of disabled submarines at great depth.*

17 Cyana, a *French three-man submersible, is capable of descent to 9,800 feet, where it can observe with TV cameras and collect bottom samples.*

18 Alvin, *undersea workhorse since 1964, can operate with a crew of three to 13,000 feet and perform a variety of scientific missions.*

19 Deep Tow *can be lowered to 20,000 feet as an unmanned, remotely controlled research vehicle for geophysical surveys.*

20 Epaulard, *unmanned, untethered French survey vehicle equipped for photography and topographic measurements, reaches 20,000 feet.*

21 Argo and Jason, *now in the design and prototype stage, will transmit television pictures from 20,000 feet (pages 830-31).*

22 Trieste, *using principles of* F.N.R.S.2, *set a historic record in 1960 by carrying a crew of two to the greatest known ocean depth, 35,800 feet.*

PIERRE MION

THIS MODEL OCEAN combines elements of both the Atlantic and Pacific. Features are not to scale.

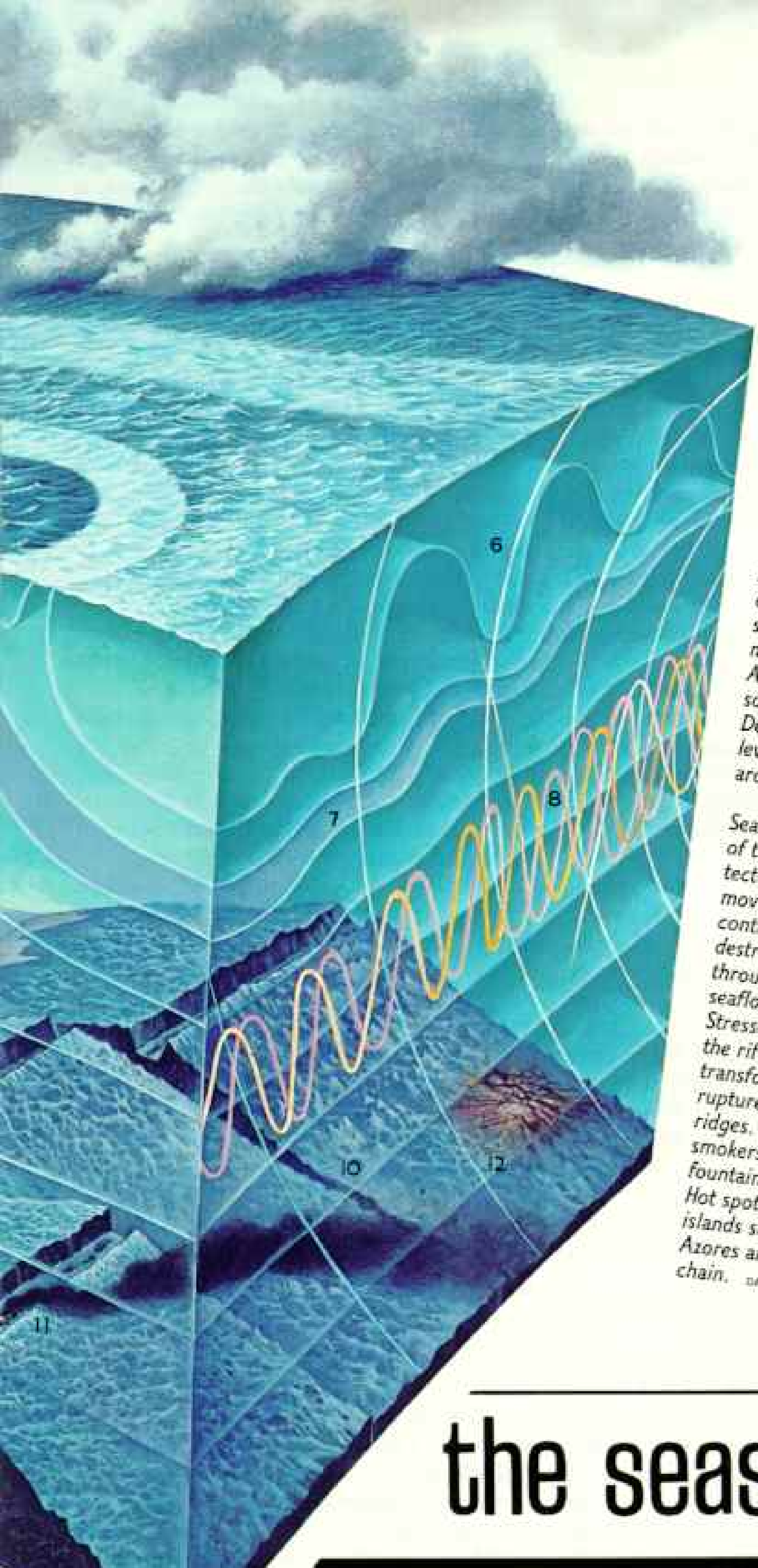
Ocean-air boundary (1) links circulatory systems. Winds drive waves and surface currents. The great heat capacity of the oceans moderates air temperatures. Water and other compounds are exchanged, altered, and cycled through both sea and atmosphere.

Surface currents (2) are deflected by earth's rotation. Slower, colder currents (3) flow near the bottom. The strongest churn silt-laden streamers from the continental slope, which deposit sediments on the seafloor.

Rotating masses of seawater, huge ocean eddies transport energy, heat, chemicals, and whole ecological systems, as well as affect oceanic circulation. Cold-core rings, the class shown here (4), may survive as coherent features for two years and more.

Deep scattering layers (5) fool depth-sounders. These large masses of shrimplike crustaceans and small fish migrate down in daylight and up at night.

Anatomy of



Internal waves form at the boundaries of different densities (6). Although much taller than surface waves, they move more slowly and with less energy.

Segregated in layers (7), ocean waters move in horizontal sheets with little vertical mixing except in the top layer and along continental margins.

Sound travel is affected by depth, temperature, and salinity. At about 1,200 meters (4,000 feet) in the Atlantic conditions trap sound in a channel (8). Detonations fired at that level can be detected halfway around the world.

Seafloor spreading is part of the process of plate tectonics, in which continents move and the ocean floor is continuously created and destroyed. Magma wells up through a rift valley (9) as seafloor plates spread apart. Stresses perpendicular to the rift may create the transform faults (10) that rupture the rift and displace ridges. Plumes called black smokers (11) are hot-water fountains spewing minerals. Hot spots (12) may build islands such as the Azores and the Hawaiian chain. DAVID MELTZER

the seas

(Continued from page 793) submersible with nuclear power. His name is Bruce Heezen (pronounced HAY-zen); he is one of the world's best known marine geologists. At 50 he has personally mapped more of the earth's surface than anyone before him. And here in the cold North Atlantic in 1977, he is soon to die of a heart attack.

In 1947, 30 summers before, Heezen was a geology student working at Woods Hole Oceanographic Institution in Massachusetts under a gruff, tireless geophysicist named Maurice Ewing. Ewing had been at Woods Hole all during the war, helping to develop sonar and other instruments such as the bathythermograph, which could take a temperature profile of successively deeper layers of the sea. Shortly he would head a new laboratory at Columbia University in New York, which was to become today's renowned Lamont-Doherty Geological Observatory.

On the Woods Hole sailing ship *Atlantis*, "Doc" Ewing went to sea as often as he could, trying to learn more about the structure of the floor of the Atlantic by dropping TNT charges and recording the echoes. That summer he had use of the *Atlantis* to explore the Mid-Atlantic Ridge, with support from the National Geographic Society. Young Bruce Heezen sailed with him, as did another student, Frank Press, who years later would become presidential science adviser and today heads the National Academy of Sciences.

East from Bermuda toward the Azores they went. Their depth-sounder, the most powerful yet sent to sea, first showed irregular terrain, then an absolutely flat abyssal plain, smooth as a vast mud flat 2,900 fathoms (17,400 feet) below the surface.

Two days later *Atlantis* found itself over bumpy foothills, then, in mid-ocean, over a wild and jagged realm of mountains, rank on rank of them, broken by huge valleys and canyons. The depth-sounder showed peaks six, eight, ten thousand feet tall—all a mile and more below the sea's surface.

They were over the ridge; they zigzagged back and forth across it for several weeks, sounding and taking dredge samples of bare, seemingly volcanic rocks. It was a far different landscape from the broad, high steppe Maury had described; it was the high barrier *Challenger*'s temperature data and *Meteor*'s soundings had shown must exist.

Ewing went back a number of times, but not for several more years—until Bruce Heezen began mapping the ocean floor, a lifelong task—did it become clear just what they had found.

The Mid-Atlantic Ridge he charted resembled the back of a huge crocodile. It rose more than 10,000 feet in places and was broken by great offsets.

Heezen and Marie Tharp, his drafting assistant, turned all the echo-sounding transects and depth recordings they could gather together, from all the ship tracks and oceanographic centers of the world, into sea-bottom profiles. Then they melded the profiles into physiographic diagrams, or sketch maps, that showed the ocean floor in three dimensions.

"When we began in 1952," Heezen told me a decade later, "only a few such profiles had ever been drawn across the Atlantic." He and Marie Tharp produced scores, then hundreds, finally thousands of them. In 1959 they published, with Maurice Ewing, *The Floors of the Oceans: I. The North Atlantic*. It accompanied the first of a series of maps that would encompass the globe.

Later their diagrams would be rendered by an Austrian mountain artist, Heinrich C. Berann, into more generalized, full-color map paintings. These were issued, one by one, by NATIONAL GEOGRAPHIC. To Heezen's great satisfaction (he was sometimes criticized by colleagues for extrapolating and drawing "poetic truths"), the maps blossomed on walls of schools and colleges—and in his colleagues' offices—the world over.

BEFORE THE FIRST appeared, however, Marie Tharp had made a historic discovery of her own. She noticed that on profile after profile of the Mid-Atlantic Ridge, a deep V-shaped valley appeared to run along the very crest, or centerline. When she first ventured that this rift might extend the entire length of the range, Heezen didn't pay much attention. The idea seemed too vague, too farfetched.

About the same time Ewing and Press and other geologists at Lamont were restudying world earthquake records. Heezen began

plotting the centers of the quakes on the detailed charts Marie Tharp was drawing.

The earthquakes followed the ridge crest—the path which Marie said held a rift valley. "It was as if a light suddenly went on," Bruce Heezen said to me long afterward. "The rift indeed was there. The earthquakes were taking place along it."

Belts of earthquakes had been charted down the Mid-Atlantic Ridge and along Indian Ocean and Pacific ridges—indeed, around the whole earth. Heezen realized that the quakes traced a far more extensive feature of the planet's hard surface than had ever been suspected: a massive scar 40,000 miles long, curving around the globe like the seam of a baseball. The Mid-Ocean Ridge, as Heezen named the system, now is known to cover as much of the earth's surface as all the continents put together.

It is volcanic and shaken by earthquakes. The fiery upthrusts of Iceland, the Azores, Tristan da Cunha, Réunion, the Galapagos are simply places where active volcanoes of the ridge system rise above water.

AS MORE and more ocean expeditions proved that the central rift was really there, other facts emerged. Great east-west displacements cut across it; the Canadian geologist J. Tuzo Wilson named them transform faults. Many of the ridge quakes came from them. Not only was there high heat flow from within the earth along the ridge; most rocks dredged from its slopes were of fresh lava. Something was going on, something massive and basic.

Almost no sediments were found on the central slopes of the ridge. Indeed, and more mystifying, nowhere in the oceans was there as much or as old sediment as there should be if the oceans were as old as the earth itself. Where had the mud and ooze gone?

"I am reasonably certain," oceanographer Roger Revelle was to say long after, "that Maurice Ewing went to his grave believing that somewhere in the deep sea there was a place where sediments of all geologic ages, back to one or two *billion* years, had been deposited one on top of the other."

Yet nothing from the ocean floors, neither sediments nor bedrock, has yet been found older than about 200 million years. Were the continents in fact drifting, bulldozing off the sediments as they went?

About 1910 both a U. S. geologist, Frank B. Taylor, and a German meteorologist, Alfred Wegener, had proposed continental drift as a serious possibility. The idea was still being laughed at by many geologists in 1960. But at the same time, in 1959 and 1960, a few bold theorists were beginning to put forward a wholly new idea: Was the seafloor itself moving, carrying the continents with it? Were the oceans growing wider?

Geologist Harry H. Hess of Princeton University and Robert S. Dietz, a Navy oceanographer, theorized that the seafloor might be spreading from the central rift system. Hess called his landmark paper "an essay in geopoetry."

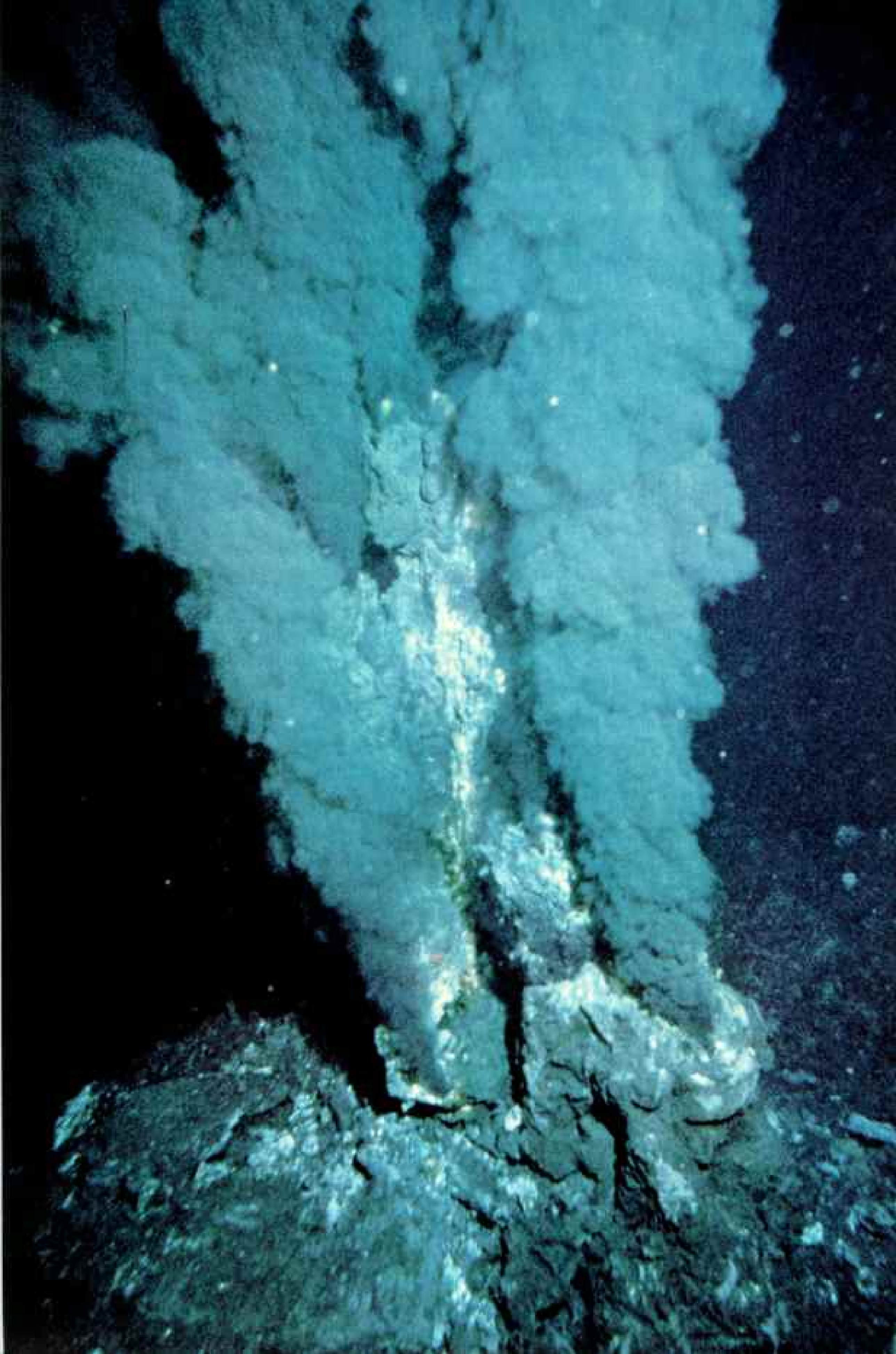
Proof came swiftly, in a tide of discoveries all through the 1960s. The major proof was as unexpected as the notion that the oceans were widening.

The earth is a magnet. Its magnetic field controls the compass needle. Its rocks, chiefly those that cooled from molten magmas, act like frozen compasses; they show the earth's magnetism as it existed when the rocks solidified, layer after layer.

Ever since World War II, earth scientists had been studying lava beds on land. In the early 1960s they discovered that the earth's magnetic field has reversed many times in geologic history. Its north and south magnetic poles have flip-flopped.

When ships towed magnetometers across the oceans, curious striped patterns emerged. In 1963 two Cambridge University physicists, Frederick J. Vine and Drummond H. Matthews, and independently a Canadian, L. W. Morley, proposed that the ocean floors might be, in effect, giant recordings of earth's magnetic history. What's more, the successive stripes of reversed magnetism proved that the seafloor was indeed in motion—spreading in both directions from the center of the ridge.

Much more proof soon came from scientists at Lamont, working under Doc Ewing: Walter Pitman, James Heirtzler, Neil Opdyke, Xavier Le Pichon, Lynn Sykes. They compared magnetic patterns from different parts of the world, assigned dates to seafloor profiles, checked them against core samples, studied earthquake zones. "It was a



time as exciting as any in the history of geology," Jim Heirtzler told me years later.

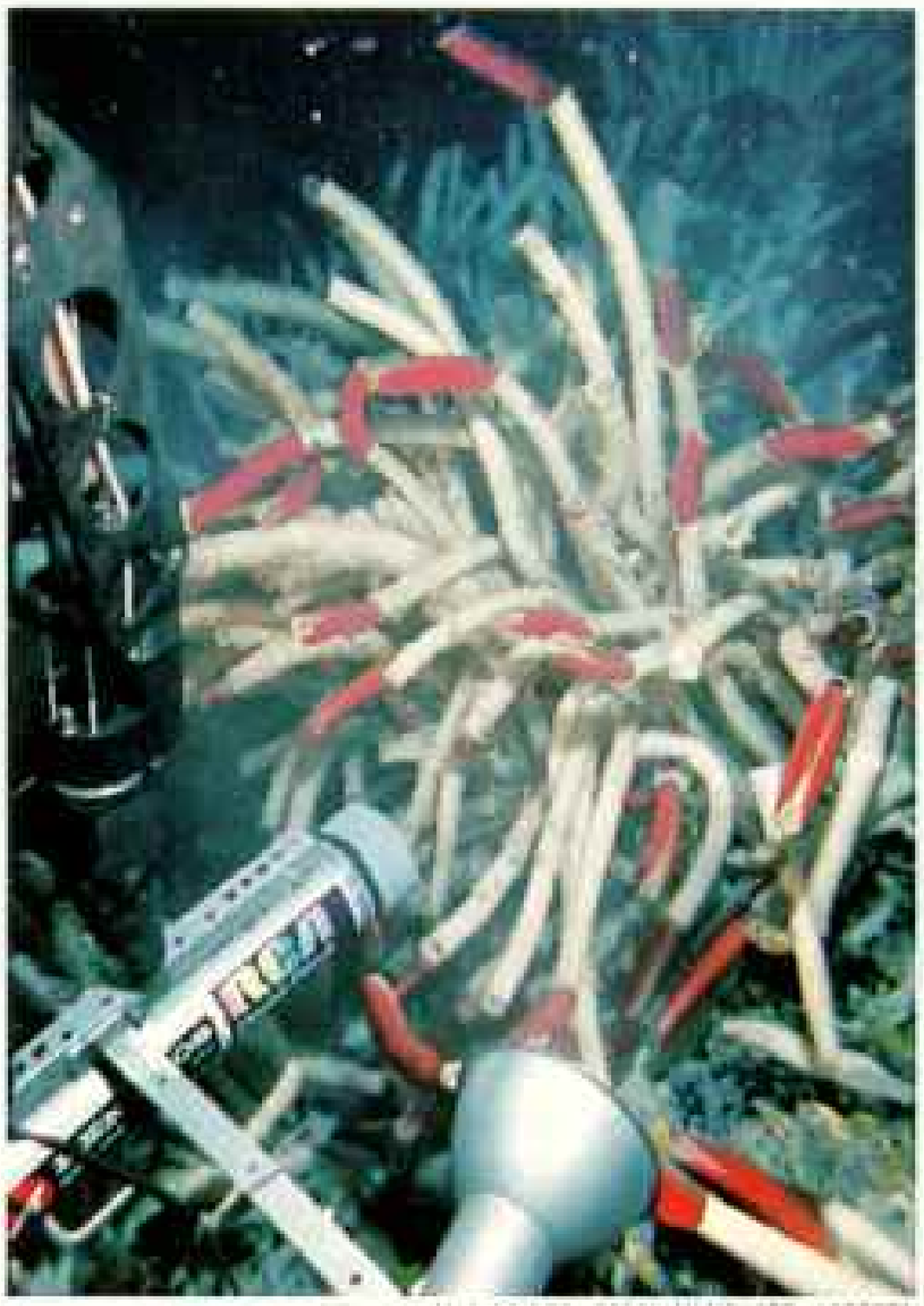
More proof came from the seafloor itself. In the 1960s an effort to drill a sampling hole totally through the outer crust of the earth, the so-called Mohole, had aborted because of soaring costs. But the Mohole Project gave birth in turn to the Deep Sea Drilling Project (DSDP). Using a specially designed oceangoing drill ship, *Glomar Challenger*, the DSDP began in 1968 to probe and sample the seafloor deeper than ever before.

From the third drilling leg came confirmation of seafloor spreading. Off the hump of Brazil, in mid-Atlantic, cores brought up from either side of the ridge showed progressively greater ages the farther out they were taken. The Atlantic was widening by nearly an inch a year—in a man's lifetime, by as much as his height.

Glomar Challenger has gone on drilling for more than 13 years. Among its remarkable discoveries:

- None of the oceans, even the oldest corner of the Pacific (the northwest), holds rock or sediment older than 200 million years.
- In those 200 million years, less than a twentieth of earth's total age, parts of the seafloor have traveled thousands of miles.
- The Mediterranean Sea has totally dried up, then refilled—perhaps more than once—within the past 12 million years.
- Earth's past climate, through ice ages and long warm spells between, can be read and mapped from seafloor cores.

Roger Revelle, who has been deeply involved in the DSDP since its inception, has termed the program "one of the great achievements in the entire history of the earth sciences."



AL GIDDINGS, OCEAN FILMS, LTD. (ABOVE); JOHN EDMOND, M.I.T. AND NATIONAL SCIENCE FOUNDATION

Rich in minerals, *water ejected from hydrothermal vents* ***(left)*** *along the East Pacific Rise contains hydrogen sulfide that bacteria use to power their metabolism. Bacteria are the basic food source for the giant tube worms* ***(above)*** *and other life near the vents. The bacteria may be similar to earth's first organisms, which, not yet able to use the sun's radiation, likely used oceanic chemicals as their energy source.*

A BULBOUS little white-hulled submarine named *Alvin*, scarcely bigger than a milk truck, has carried scientists into rifts in the earth's skin in both the Atlantic and Pacific. As a ship of discovery, in this age of exploration, it has done as much as *Glomar Challenger* to open new frontiers.

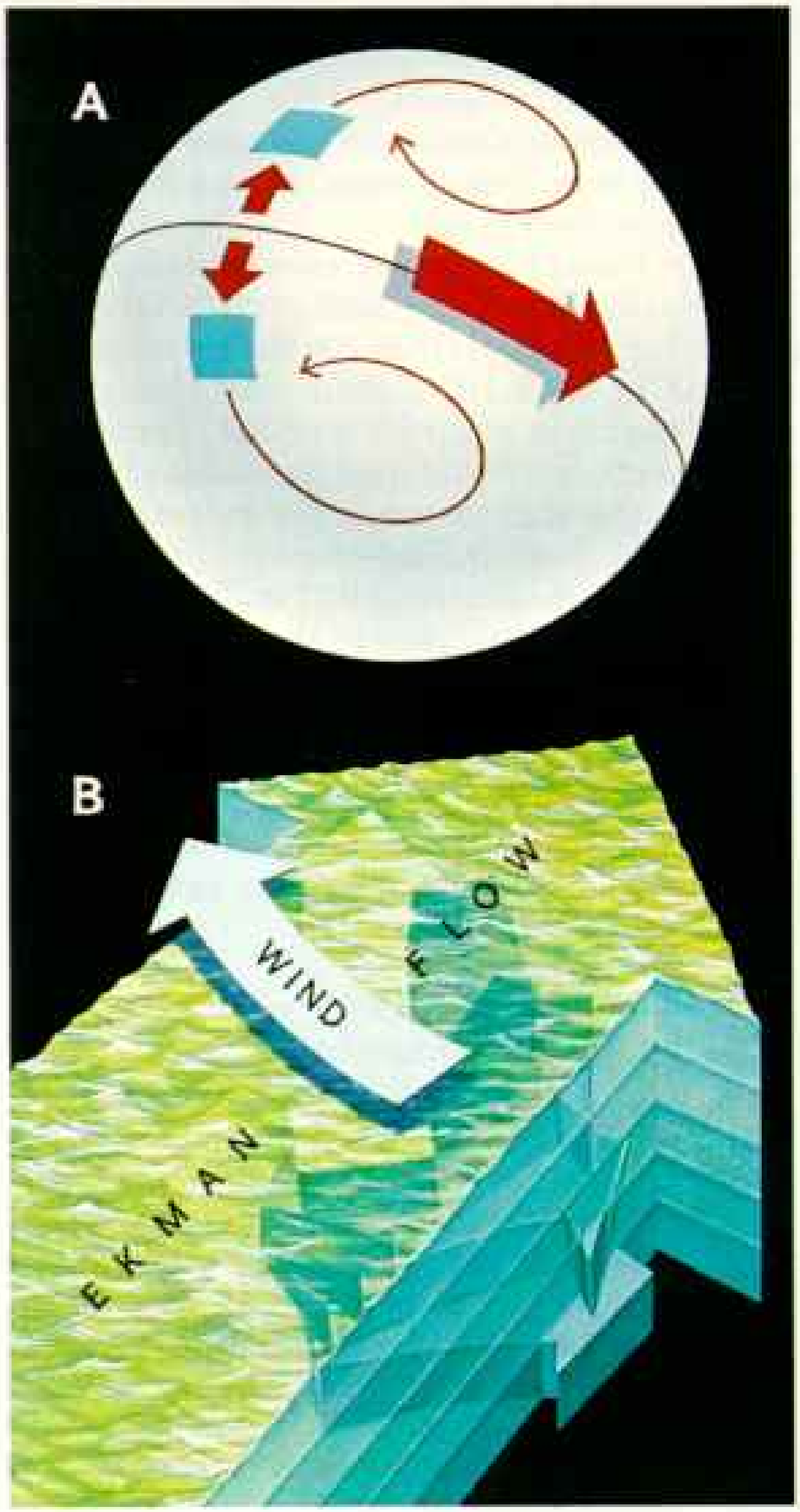
In July 1974, southwest of the island of São Miguel in the Azores, *Alvin* took Jim Heirtzler and other U. S. geologists 2,800 meters (9,100 feet) down to the central rift of the Mid-Atlantic Ridge. The dives were a key part of Project FAMOUS—French-American Mid-Ocean Undersea Study.*

One of the younger scientists with Heirtzler's team was Robert D. Ballard; he had dived the year before at the Azores site in the French bathyscaph *Archimède*, a cumbersome undersea dirigible filled with aviation gasoline for buoyancy.

"When we first laid eyes on the glassy black, obviously fresh lava on the floor of the rift, it was as if there in our floodlights lay the true birthplace of the earth's crust," Ballard has described those dives to me.

Pillowlike blobs and fractured tubes of black lava appeared to have been formed

*The May 1975 GEOGRAPHIC described these first descents to the Mid-Atlantic Ridge.



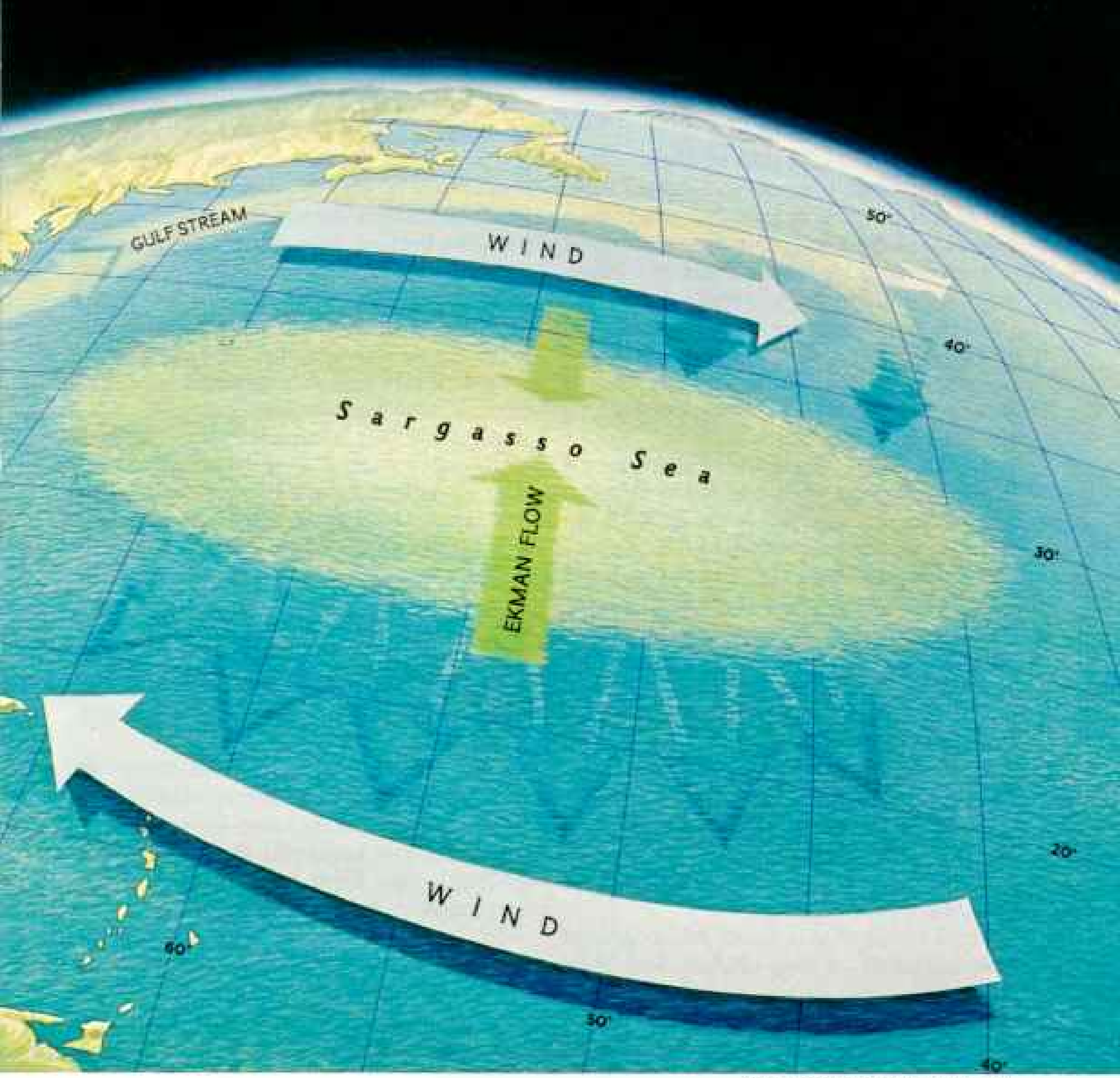
Currents on the Coriolis merry-go-round

ALL THE WORLD'S rivers times five—that is the volume of the Gulf Stream. The direction of this prodigious current is ultimately controlled by the Coriolis effect, a phenomenon that deflects all motion as a result of earth's rotation. (This deflection can be shown by trying to draw a straight line across a piece of paper mounted on a moving record-player turntable.)

In the Northern Hemisphere, motion is deflected clockwise; in the Southern Hemisphere, counterclockwise.

*If sections of ocean are thought of as frictionless slabs, one being pushed north from the Equator and one being pushed south, they would move as shown (**diagram A**). These spiraling curves are due to the Coriolis effect.*

*But there is friction, and it affects the slabs of water. Each slab is like a stack of layers, the whole extending 50 meters down (**diagram B**). Wind pushes the top layer, which is deflected to the right*



NATIONAL GEOGRAPHIC ARTIST WILLIAM H. BOND

by the Coriolis effect. The second layer down is deflected slightly more to the right by the drag of friction, and so is each layer in turn, until the bottommost is moving in a direction nearly opposite to the wind, but with much less force.

As a net result, the average movement is at a right angle to the wind, a motion known as Ekman flow.

In the North Atlantic (**diagram C**) *westerly winds at mid-latitudes and easterlies at lower latitudes push water to their respective right by means of Ekman flow. These flows converge in the Sargasso Sea, pushing the ocean surface into a hump hundreds of kilometers across and a meter high.*

Because of its weight, this hump exerts downward pressure and spreads out as if it were a plumped pillow someone sits on.

Through a complex conjunction of forces, the squeezed pillow of water is displaced toward the Equator. So there must be a return flow to the north to replace the water moving south.

The return of north-flowing water might be broad and slow, since it is the volume of replacement that counts. In reality, the return flow is trapped between the coast of North America and the Sargasso Sea. Since the flow is narrow, it must deliver the required volume by speed—hence the Gulf Stream.

It too is deflected to the right by the Coriolis effect and so reinforces the great pattern of clockwise circulation.

perhaps only a few centuries ago—an eye blink in geologic time. But no actual eruptions were seen taking place.

A decade earlier, in 1963 off the southern shore of Iceland, a new island named Surtsey had risen amid steam and ash from a seabed vent. Similar eruptions had occurred in the Azores in 1957, from a seabed volcano off Faial, and in 1961 at Tristan da Cunha. One is happening today at the southeast end of the Hawaiian chain, where a new island aborning, named Loihi, already stands some 8,800 feet above the seafloor with its top still 3,220 feet underwater.

Early in 1981, on a less violent seafloor, I learned firsthand what it is like to visit this new world. Off St. Croix in the U. S. Virgin Islands, under more than 3,000 feet of the Caribbean Sea, I sat cross-legged and cramped inside *Alvin*'s seven-foot-wide pressure sphere, bending awkwardly to peer through a tiny Plexiglas view port at a flood-lit patch of dun-colored ooze.

The dive on which I accompanied Woods Hole electronics specialist Jim Akens and pilot George Ellis was to test a new ultra-sensitive TV camera. "Silicon intensified," they said knowingly. "Single-frame scan, 200,000 ASA equivalent."

To me this was so much space jargon . . . and then, music of space!

From a loudspeaker inside *Alvin* came an eerie ululation, a high-pitched *Star Wars* tremolo. We were hearing an image being recorded, then transmitted as a high-speed sonic signal to the sub's tender far above us.

The picture that would result was of a prosaic test target, a canvas panel painted with black and white squares. As *Alvin* rose from the bottom, rose silently and surprisingly fast, the target vanished from our view ports. But it remained, shrinking and dimming yet still discernible, on a miniature video screen above our heads in the sphere.

For me this was an experience of a lifetime. It was also an oceanographic milestone: *Alvin* was making the largest images of the deep seabed ever recorded, three-quarters of an acre at a time, in swaths 210 feet across. Its newest electronic wizardry was vastly broadening scientists' ability to see landscapes that have been shrouded in utter darkness and crushing pressure since the oceans themselves were born.

OCEAN-FLOOR PLATES collide, shift along giant faults, or crack and spread apart.

Two narrow, water-filled splits on the flanks of continents—the Gulf of California and the Red Sea—are oceans of the future just beginning to open, marine geologists say. Their basins are widening; heat comes up from below their floors.

In Mexico's Gulf of California great volumes of sediment carried down by the

Rigors of the sea *present ever deepening challenges as the search for new oil reserves accelerates. In the inhospitable North Sea off Norway, one of a small fleet of tugs holds a drilling platform in place* ***(left)*** *after gale-force winds pulled three of the platform's anchors from their moorings. For working around the base of the North Sea's massive rigs, Perry Oceanographics, Inc., designed the mobile diving unit at right, a sort of underwater helicopter that permits manual operations down to 1,000 feet.*

NATIONAL GEOGRAPHIC PHOTOGRAPHER EMORY KRISTOF (ABOVE); WILLIAM R. CURTSINGER

GUILLERMO ALDANA E. (ABOVE); HERMAN J. KOKOJAN, BLACK STAR

Fire on the water *marked the world's largest oil spill* ***(left)****, touched off in June 1979 by the blowout of Ixtoc I, a well in Mexico's Bay of Campeche. Spreading northward* ***(right)****, a foamy slick dubbed "chocolate mousse" spotted the Texas coast, though favorable currents may have prevented permanent environmental damage. Nine months later 140 million gallons had spewed into the Gulf of Mexico, intensifying the search for new spill-prevention and containment technology.*

Colorado River mask the seabed rifting. Someday that rift may rip north, open a seaway through Nevada, and break away much of California as an island.

In the Red Sea, in several deep basins or holes, a different sort of mud exists. Not only is it hot—more than 60°C (140°F)—but it contains incredible amounts of minerals: silver, lead, zinc, copper, iron, and others. The top 30 feet of ooze in one of these basins, the *Atlantis II* Deep discovered by Woods Hole in the early 1960s, is potentially worth billions of dollars. Though commercial interest has been great, exploitation has been held back by legal and technical factors.

Ever since the first *Challenger's* cruise a century ago, it has been known that potato-size lumps rich in manganese and iron cover wide areas of the ocean floor, almost as thick as cobblestones. The nodules also hold copper, nickel, and cobalt. All that is needed is to lower a dredge and scoop them up.

The twin mysteries of exactly how these nodules form, and what keeps most of them unburied by seafloor ooze, remain to be solved. But careful estimates, particularly in mid-Pacific, show that enough exist to supply the entire world's needs for manganese, an important ingredient of steel, indefinitely; they are being formed on the ocean floor faster than they could be mined.

Giant firms have gone into international partnerships to plan and test methods for recovering this sea-bottom bonanza (pages 814-15). Inability of the world's nations to agree on a Law of the Sea treaty, however, has delayed the start of deep-sea mining for more than ten years. But it will surely come, for the stakes are huge.

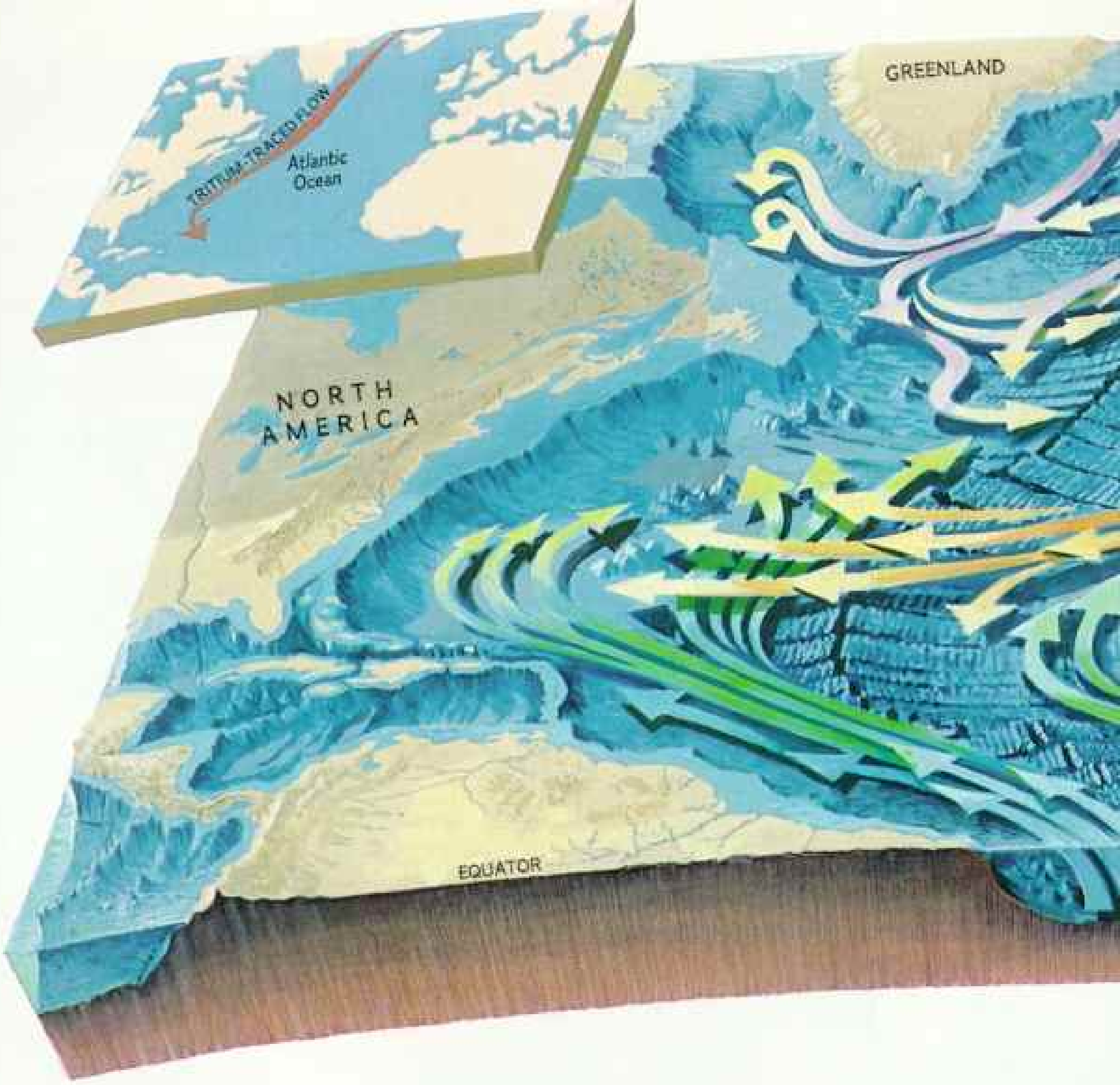
When seafloor spreading and magma upwelling were first recognized in the 1960s, geologists soon speculated that other minerals—extracted from deep in the crust by hot-water circulation—might be deposited along the mid-ocean rifts.

In Project FAMOUS, the French found an inactive vent surrounded by mineral deposits. Elsewhere along the Mid-Atlantic Ridge to the south, ships of the National Oceanic and Atmospheric Administration (NOAA) had earlier photographed a hydrothermal field. But it was not until 1979 that explorers of the eastern Pacific floor came face to face with minerals actually spewing from vents in the seabed.

Alvin, from its ungainly twin-hulled tender *Lulu*, had been diving north of the Galapagos Islands, on a rift where warm springs and strange colonies of life had been discovered two years before. Now the submersible had come north to a site on the East Pacific Rise near latitude 21° North.*

"The first dives were unbelievable," said Bob Ballard, who has traveled along more of the sea-bottom rifts than any other man on earth. "Here were these fountains of black or white material, like smoke, billowing from *(Continued on page 816)*

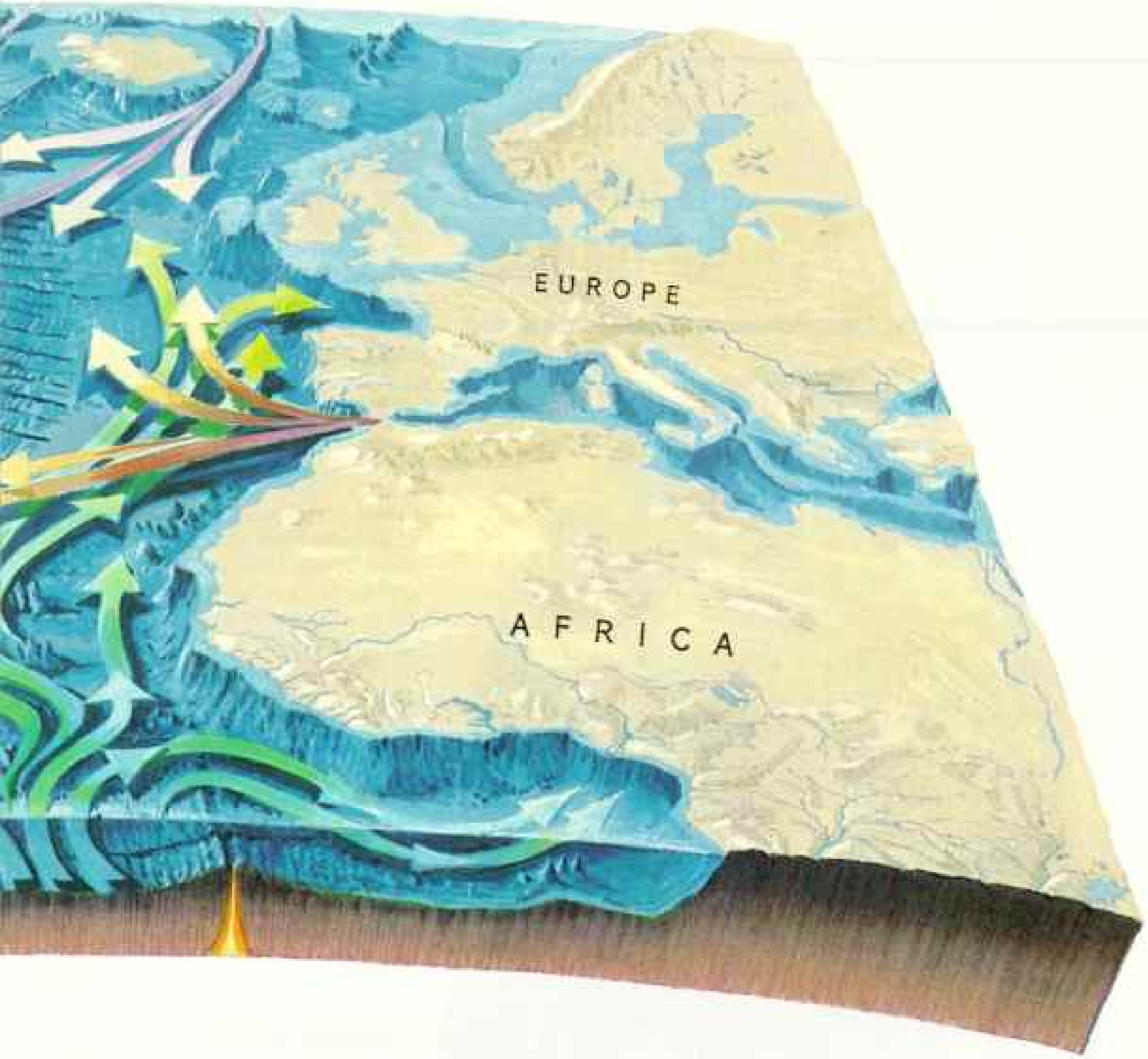
*Reports on *Alvin's* Pacific dives appeared in the October 1977 and November 1979 GEOGRAPHICs.



Tracing the layered rivers of the deep

TO UNDERSTAND how waters of the deep ocean circulate, it is necessary to know where they come from, how they flow through a basin, and to what extent they mix. Water masses have individual signatures that depend on temperature, salinity, or other chemical constituents.

In the diagram of the Atlantic (**above**) *arrows indicate the flow of cold Arctic (lavender) and Antarctic (blue) waters that hug the ocean floor. Warm, light, salty Mediterranean water (red) stays at mid-depth; one component moves north, where it will mix, sink, and return south. Testing of hydrogen bombs* (**right**) *released radioactive tritium. Rained into the ocean, this provides a clock to trace the movement of a water mass, as from the Arctic* (**inset**), *and determine rates of diffusion and mixing.*



LLOYD K. TOWNSEND (ABOVE); COMMISSARIAT ENERGIE ATOMIQUE (FRANCE)

To mine a new lode of nuggets

LIKE POTATOES and even more common—their total weight in the Pacific is estimated at 1.5 trillion tons—manganese nodules litter sections of the seafloor, with greatest concentrations at 5,000 meters (16,000 feet). They were discovered during the world's first great oceanographic voyage, begun in 1872 by H.M.S. Challenger. Why they grow is still something of a mystery, but their potential value is enormous.

Rich nodules are composed of 25 percent manganese, 1.2 percent copper, 1.5 percent nickel, and 0.2 percent cobalt.

Nodules begin to form around some foreign body, such as a shark's tooth (white airfoil shape at center of cross section, **left***). Gradually, metal oxides build around it. Smaller nodules may be encased to make a larger one, as at left. The entire accumulation may take several million years to complete—yet somehow most remain unburied by sediment.*

With mineral reserves dwindling and lines of supply less secure, mining the nodules may become economically feasible, although the capital and technology required are formidable.

*Lockheed has developed a working prototype (***right***) for Ocean Minerals Company, a consortium of corporations. Propelled by Archimedes' screws, the bottom-traveling miner collects, washes, and crushes the nodules, then pumps the slurry past a flotation block that keeps cables and hoses off the bottom. The slurry enters a hopper-shaped structure called a buffer, where it is pumped through rigid pipe to a surface ship five kilometers above.*

The biggest impediment to full-scale mining is the unclear status of international law to settle the questions—who has the right to mine the oceans, and for whose benefit?

NATIONAL GEOGRAPHIC PHOTOGRAPHER VICTOR R. BOSWELL, JR. (ABOVE); NATIONAL GEOGRAPHIC ARTIST NED M. SEIDLER

(Continued from page 810) crevices and hollow rock pillars along the rifts [page 804]. They made me think of Pittsburgh's smokestacks a generation ago.

"We drove *Alvin* up to one of the black smokers. Our claw thrust a plastic heat probe into the vent. The temperature recorder in the sub went off scale. Then we saw the plastic rod itself begin to melt, to droop like taffy. It didn't take long to realize *Alvin*'s portholes might not stand such temperature [later calculated to be above 350°C—650°F]. We backed off in a hurry!"

More cautiously, time after time, *Alvin*'s pilots and scientists nosed as close as they dared to other such geysers, made film and television images, and brought up samples of bright-colored minerals—sulfides and oxides of copper, iron, and zinc.

The fact of hydrothermal mineral formation in the oceans, which earlier was simply theory, is one more milestone discovery. It opens the way for more confident prospecting on land, and someday for mining the seabed itself. For the oceans, it is now clear, will inevitably be man's next mother lode for many of the natural resources he must have.

Today the United States draws 12 percent of its domestic crude oil from offshore wells—in the Gulf of Mexico, off California and Alaska. Soon it may tap its Atlantic shelf as well. Worldwide, a fifth of all oil and gas now comes from under the oceans.

Finding it, extracting it, and bringing it ashore safely have spawned extraordinary new industrial tools and techniques: Drill platforms taller than the Washington Monument stand amid the smashing waves of the North Sea; floating rigs ride on hulls submerged far under the surface; storage tanks, ship-loading terminals, and pipelines rest on the seafloor itself, from Persian Gulf to South China Sea to Gulf of Mexico.

All this too has happened largely in the past 30 years. The offshore oil industry depends on the ability to "see" rock layers deep within the sea bottom, using seismic echoes, computers, neutron emitters, heat probes, and gas sniffers.

The oil wells offshore, and the tankers that endlessly plow the oceans, bring great dangers as well. The chances of polluting the seas, possibly causing irreversible damage to their life forms and the shores they wash, grow with every offshore discovery, every supertanker leaving port.

Capt. Jacques-Yves Cousteau, roaming the world's seas for the past 31 years in his *Calypso*, now finds tar balls and other oil traces wherever he goes. "The oceans are sick and in trouble," he says grimly.

OCEANOGRAPHERS in these 30 years have learned almost as much about the waters of the seas, and how they move, as they have about the vast mountain ranges of the seafloor.

When World War II ended, the charts of surface currents, wind patterns, tides, and wave patterns were the legacy of centuries of shipmasters' lore, of Matthew Maury's "Sailing Directions," of sealed bottles cast adrift during pioneering cruises of research ships, but primarily of data gathered by competing—and often warring—navies.

Today the charts have been largely redrawn by instruments developed for peaceful research. With buoys that broadcast from mid-ocean for years and floats that drift great distances at constant depths beneath the surface, with hydrophones that pick up sonic signals from afar, with long-distance aircraft and cloud-piercing satellites that record sea ice and warm currents from space, physical oceanographers have refined their concepts of ocean circulation.

It was known that cold water from the polar regions creeps slowly at great depth toward the Equator, to replace warm surface currents, such as the Gulf Stream, that carry the sun's heat to high latitudes. In these few decades, however, it has been learned just how far north Antarctic bottom water reaches—to the northern limits of the Atlantic, Pacific, and Indian Oceans.

Massive currents and countercurrents beneath them flow in opposite directions along the Equator and the edges of continents. They help the oceans turn over and mix in as little time as a thousand years—an important control over climate.

In studying the North Atlantic, Bruce Heezen and Maurice Ewing recognized the tracks of tremendous undersea mud avalanches, called turbidity currents. The slides explained many things: why there are giant undersea ravines and valleys, such as the Hudson Canyon off New York; why

submarine cables to Europe broke; why sand—a shallow-water substance—could come up in core samples taken far offshore. Heezen and Ewing analyzed one specific slide, set off by an earthquake in 1929 on the Grand Banks of Newfoundland, that broke more than a dozen transatlantic cables, one after the other.

In recent years drift buoys and satellite pictures have confirmed that the Gulf Stream is far from a smooth, straight river. Instead it meanders, twists, even forms great loops and eddies (pages 794-6) as it carries its load of tropical heat from the Caribbean to warm northern Europe.

In 1973 the United States and Britain joined in a project named MODE (Mid-Ocean Dynamics Experiment) to detect and track the great eddies of Atlantic water swirling slowly across a 270-mile-wide patch of ocean between Bermuda and Florida. Again in 1977-78, American, British, Soviet, Canadian, French, and West German oceanographers cooperated in an even larger program, called POLYMODE, in several areas of the Atlantic.

From such studies it became apparent that as much as 99 percent of all the energy in the motion of the oceans may be involved in eddies. Yet within these massive movements, distinct layers may be recognizable even after moving great distances.

"One, south of Bermuda, was so salty that its water could only have come from the Mediterranean," Dr. Thomas Rossby of the University of Rhode Island, one of the U. S. designers of MODE and POLYMODE, told me. "Yet the layer, some 60 miles across and 1,640 feet thick, retained its identity all the way across the Atlantic."

Woods Hole researchers have marked and tracked strange rings breaking off the Gulf Stream, seeking their cause and dynamics. Occasionally a slow whirl will totally enclose a pocket of either colder or warmer water, like a huge life ring or standpipe revolving in the sea. Fish and other life will not leave one type of water for the other, but stay within their natural revolving swimming pool as long as it remains unbroken.

Scripps Institution of Oceanography in California has long taken the Pacific as its lake, logging hundreds of voyages of discovery. Its ships found great fractures in the eastern Pacific floor, and in the north and west sounded the Aleutian, Japan, and Philippine Trenches, and, deepest of all, the Mariana Trench.

Thor Heyerdahl drifted with *Kon-Tiki* west from South America on the South Equatorial Current, 4,000 miles to the Tuamotu Islands. Scripps scientists traced the equally massive Cromwell Current flowing eastbound beneath it, to wash cold water up against the volcanic Galapagos Islands and support the fantastic, isolated life forms that Charles Darwin saw there.

The north-flowing Peru, or Humboldt, Current and upwelling of deep, cold water along the western flank of South America feed one of the richest fisheries in the world. But the region is subject to vagaries of atmospheric and oceanic forces thousands of miles away. Occasionally a great mass of warm water invades from the north and blankets the upwelling. Then, in those dread times called El Niño (The Child), the Peruvian fish catch fails and the world faces a shortage of protein for animal feed—and, ultimately, human sustenance.

IN LONG, air-conditioned storage rooms at Scripps and Lamont stand rack after rack of cores—cylindrical tubes of mud and clay, sand and rock. These are taken from the seafloor by sharp-edged pipes dropped like bombs from oceanographic ships or brought up through *Glomar Challenger's* drill pipe.

Maurice Ewing, in a day when a single core sample ten feet long was a treasure that might take a year to analyze and fully write up, confounded his colleagues by bringing home cores by the scores, then by the hundreds, every time his *Vema* and *Robert D. Conrad* docked from world cruises.

But the results in new knowledge were immediate and dramatic; every other oceanographic institution was soon to emulate him. Then came the years of the Deep Sea Drilling Project, and the cores proliferated even faster.

"A competent marine geologist can read down the length of a seabed core and tell you the state of the ocean surface over a million years, and from that the earth's changing climate," Lamont-Doherty's Dr. James D. Hays *(Continued on page 824)*

Maritime politics makes strange bedfellows *of United States and Soviet fishermen, who now cooperate in harvesting the ocean. In the Bering Sea north of Alaska's Aleutian Islands, the U. S. ship Viking hauls in 20 tons of cod to be transferred to the Soviet ship Nadezhdinsk, at top, for processing. In return for*

DAVID FALCONER

cleaning, filleting, and freezing the fish, the Soviet ship shares in the proceeds. This arrangement helps compensate for lower quotas imposed on foreign vessels by the federal Fishery Conservation and Management Act, enacted in 1976 to prevent overfishing within 200 nautical miles of the U. S. coastline.

A perishable catch *means brisk work aboard the Soviet factory ship 18 Syezd VLKSM* ***(left)****, brimming with cod and pollack pulled from the Bering Sea by the U. S. trawler Royal Atlantic. Belowdecks the Soviet ship holds a space-efficient processing plant, where workers in white hats, masks, smocks, and gloves remove parasites as a conveyor belt carries the fish to deheaders, filleting machines, and flash freezers.*

To preserve the fishing grounds, the United States keeps a close eye on operations. Beth Dunning, a Russian-speaking biologist, inspects a catch on the 18 Syezd VLKSM ***(right)****, to which she is assigned for two months. She monitors the size and predominant sex of the hauls and orders certain species thrown back. Foreign ships are prohibited from taking crab, halibut, salmon, and other prized seafood. Vessels found to possess forbidden species are subject to seizure by the U. S. Coast Guard.*

Such problems were put out of mind in April 1980, when arrangements for a new U. S.-Soviet fishing venture were worked out in the U.S.S.R. at Nakhodka. Capt. Barry Fisher of Newport, Oregon ***(right,*** *at right), locked arms in the Russian manner with the Soviet fleet commander Ivan Petrovich Samsonov for a toast to the partnership.*

ALL BY DAVID FALCONER

Underwater gardens *yield a tangled crop of seaweed at Qingdao Kelp Farm in the north China province of Shandong (**above**). The Chinese produce more than 150,000 dry tons of kelp a year, half for food and half for alginates, which act as stabilizers and emulsifiers in medicines, food, and cosmetics.*

The nation's most abundant kelp is a brown, cold-water

BOTH BY EMORY KRISTOF

species introduced from Japan. Using methods developed by the Japanese after World War II, the Chinese raise kelp sporelings in shallow tanks. In the fall the plants are attached to buoyed ropes and grow as long as 20 feet before being harvested in the spring. Today China exports kelp to Japan, where production has declined in recent years.

*At the Chinese Academy of Sciences' Institute of Oceanology in Qingdao (Tsingtao), deputy director C. K. Tseng (**left**, at right) works on developing a warmwater variety that can be cultivated as far south as Shanghai. By X-ray mutation and selective breeding, researchers are perfecting strains with a substantially higher iodine content to combat goiter, a common ailment in China.*

(Continued from page 817) told me a few years ago.

By examining under microscopes the skeletons of tiny marine organisms—foraminifera, radiolarians, and such—in the cores, Dr. Hays and his colleagues can read the temperature of the sea surface when the creatures lived, then died and drifted down in a slow, constant rain to the seabed. They can tell as well the amount of ice in the world—how much fresh water, fallen as snow, remained locked up in ice caps and glaciers in those dim past ages.

They have known, for example, that about 65 million years ago, at the end of the Cretaceous geologic period, a sudden catastrophic extinction of surface-dwelling ocean life occurred. It happened very close to the time that the dinosaurs, equally mysteriously, died out on land.

In May 1980 *Glomar Challenger* brought up 655 feet of core from a 70-million-year-old ridge in the Atlantic off South Africa. In it the shipboard scientists found a clear record of that "boundary event." A layer only 23 feet thick, datable by fossils, showed that the mass extinction took place in less than 100,000 years, within 500,000 years of the time the dinosaurs were gone. Sea-surface creatures that previously had thrived disappeared, leaving only a few species of minute plants and animals. It took several million years for the diversity of ocean life to reappear.

Studies of sedimentary layers on land in Italy, Denmark, and Spain, show the same sudden kill-off. Coincidentally in 1980, chemical studies of those layers revealed abnormally high amounts of exotic elements such as iridium, arsenic, and antimony.

The conclusion reached by some scientists, among them Nobel laureate Luis Alvarez and his son Walter, of the University of California at Berkeley, is that the planet was struck by an asteroid or comet as big as six miles across. Such a collision would have thrown vast quantities of dust into the atmosphere and scattered traces of heavy metals worldwide. The screening of sunlight from the land and sea for several years could have led to a massive kill of plant and animal species. "The lights went out, and that stopped the food chain," says Luis Alvarez.

Marine geologist Cesare Emiliani of the University of Miami in Florida, however, believes that the asteroid fell into the ocean and caused a sudden temperature rise. "This," he says, "could have brought the selective extinction of the dinosaurs and other animal and plant groups."

Other researchers speculate instead that continental drift may have suddenly changed ocean circulation and killed off the sensitive Cretaceous life forms. The Arctic basin, blocked from the infant North Atlantic, may have suddenly released cold, relatively fresh water into the highly salty young sea to the south, and the shock to life there could have wiped out much of it. Climate around the Northern Hemisphere could have cooled enough to undo plant life on land, and thus the dinosaurs.

NOT JUST long-term climate but day-to-day, week-by-week weather patterns are affected decisively by sea conditions, meteorologists are learning. "The bad North American winters of 1976-77 and 1977-78 are related to ocean-surface temperature changes in the North Pacific," climatologist Jerome Namias of Scripps has told me.

When the jet stream over the Pacific changed in 1976, Dr. Namias said, California suffered winter drought, while paralyzing cold and snows gripped the Northeast. Three years later, just the opposite happened: California and the Northwest were deluged by rain and snow while the East went bare.

Changes in currents and cold-water upwellings along the flanks of continents produce drastic changes in fisheries, and the vital resource they provide for millions of people. El Niño disrupts the Peruvian fish catch for years at a time. Upwelling along the Arabian Peninsula, the shores of Pakistan and India, and elsewhere supports great fish populations as well. Should such upwellings fail, or should the monsoons controlled by the sun and the seas change, millions of people would go hungry.

Blooms of algae and other plankton, some causing the so-called red tides, kill or nourish pelagic fish. Conversely, the steady decline in whale populations over a century of more and more efficient hunting by whaling fleets has brought an apparent increase in

Ever inventive *Harold E. Edgerton developed the first high-speed electronic flash, or strobe, which revolutionized photography above and under the sea. In 1954 he used an early version of his deep-ocean camera* (**above**)*; a later model operated to depths of eight kilometers (five miles).*

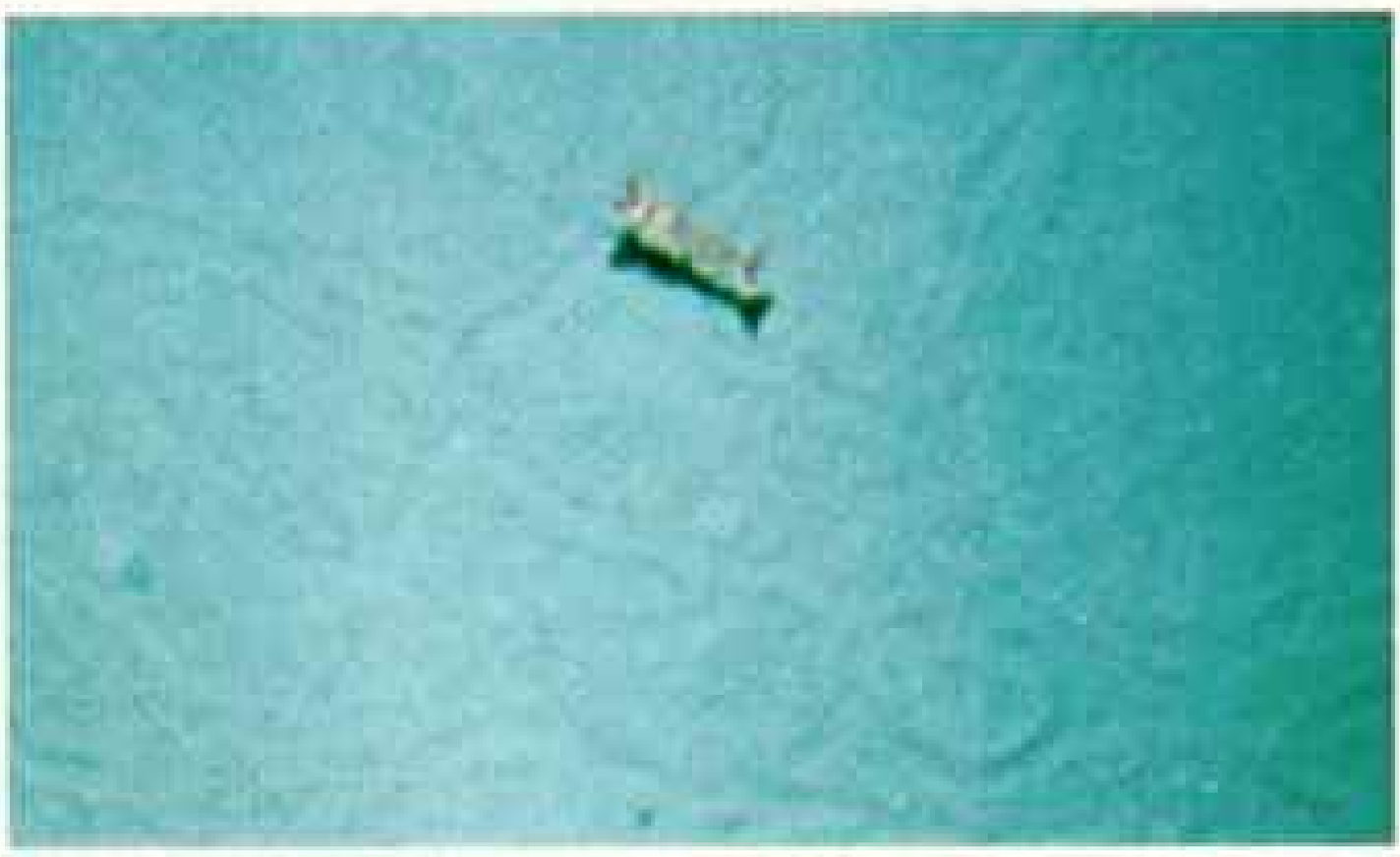
Recently he has turned his skills to a central problem in the study of plankton—no adequate means had been devised to analyze a sample quickly and accurately. Dr. Edgerton constructed a silhouette camera that can photograph plankton in their natural state in the sea. With high resolution, a single image (**right**) *can encompass about 260 cubic centimeters of seawater—enough to permit scientific study without having to crush the animals in nets or requiring tedious microscope work.*

BOTH FROM HAROLD E. EDGERTON

EMORY KRISTOF (ABOVE AND RIGHT)

A window near the North Pole *was cut in Arctic ice by a team* ***(above)*** *preparing to photograph in the world's least explored ocean. Divers monitored the descent of a National Geographic-designed camera* ***(right)*** *on its plunge to record life at 4,300 meters (14,000 feet). Only shrimp appeared* ***(below)****, although tracks in the mud gave evidence of benthic organisms.*

The project was a part of LOREX, a comprehensive Canadian expedition based on an ice floe that drifted two miles a day over and around the Lomonosov Ridge, 1,800-kilometers long and rising as much as 3,000 meters from the Arctic Ocean's floor. Canadian scientists used seismic devices, bottom-coring samplers, current meters, and other gear for basic scientific inquiry. Their work may also lead to discovery of resources such as petroleum.



EMORY KRISTOF AND SAMUEL RAYMOND, BENTHOS

the drifting meadows of shrimplike krill, on which the great whales graze.

There is so much krill in Antarctic waters, some experts say, that an efficient and controlled harvest on a sustained-yield basis could produce more food for the hungry world than all its fisheries put together. The only trouble is, not many people have developed a taste for krill. But the Japanese, for one, are freezing, drying, grinding, and otherwise preparing it for human consumption. In Tokyo's 50-acre Tsukiji fish market, I wandered among long tables covered with krill, krill flour, krill paste, dried and frozen krill hard to tell from shrimp.

Modern fishing fleets are marvels of efficiency. Freezerships serve the catchers, which swarm around fishing grounds. Danger of overfishing and irreversibly depleting stocks worries many nations. The extension of national boundaries 200 nautical miles offshore in the 1970s was largely impelled by the drive to protect ocean fishing.

At the same time, efforts to "farm" fish and other seafood have burgeoned. The Japanese cultivate oysters, shrimp, prawns, abalones, and fish of many varieties for food. Today China, as well, is fast expanding its mariculture—kelp, for example, is grown offshore like corn (pages 822-3), and sea cucumbers, a sort of giant slug the Chinese relish, are harvested from the bottom. More food can be taken from an acre of seawater than from an equal area of farmland.

For centuries the Chinese have grown fish in farm ponds. U. S. scientists have inspected communes that grow three or more species of fish layer above layer in the same waters. "At one such fish farm near Shanghai," Woods Hole biologist John H. Ryther reports, "carp swim through the ponds, some subsisting on grass and other vegetation cuttings thrown in, some on plankton fertilized by the manure of commune animals such as ducks and pigs, and others on bottom-dwelling mollusks. A many-storied food factory!"

With scientists from half a dozen U. S. institutions I met the NOAA vessel *Oceanographer* in Shanghai in 1980, the first U. S. government ship to visit China in more than 30 years. It joined Chinese research vessels in measuring the quantity and content of sediment carried down the caramel-colored Yangtze to the East China Sea. The Yangtze and Yellow Rivers together discharge almost as much silt as do all the rivers of North and South America—four times as much material each year as lies in the Great Wall of China. Their flow provides direct evidence of the slow, inexorable wearing away of the continents into the oceans.

F. G. HALL LABORATORY, DUKE UNIVERSITY MEDICAL CENTER

Reacting under extreme pressure—*the equivalent of 686 meters of ocean depth—a volunteer is tested for loss of coordination while picking up BBs with tweezers. The Duke University Medical Center experiment early in 1981 proved the value of adding nitrogen to helium and oxygen to minimize tremors, nausea, and fatigue, and set new records for depth and duration in simulated dives.*

IN RECENT YEARS, marine biologists have discovered new types of sea life almost with every expedition. With midwater nets they solved the mystery of the deep scattering layers, which had puzzled operators of sonar and depth-sounders in wartime—mysterious blankets or surfaces that moved upward at night, descended deeper by day. They consist of masses of light-sensitive plankton, small fish, and shrimplike crustaceans, living and moving just at the lower limit of sunlight's penetration in the oceans.

Submersibles such as *Alvin*, diving through such a layer, passed other forms

that carry their own headlights, luminescent organs for either attraction or defense. To the scientists falling through them, as to William Beebe in the 1930s, they seemed like lighted snow drifting upward.

On the Galapagos Rift, and again at 21° North, the explorers found not only new species—possibly even a new phylum—but also an entirely new system of life, one not dependent on sunlight at all.

In warm water rising from rift vents, bacteria in amazing multitudes grow—metabolize—on inorganic chemicals, mainly hydrogen sulfide. This chemosynthesis, as biologists call it, takes the place of photosynthesis, the process of organic growth powered by the energy in sunlight.

The hordes of worms, crabs, clams, mussels, and other creatures discovered around the vents form a life system unknown in shallower water or on land. The discovery has been hailed by Woods Hole biologist Holger W. Jannasch as "so fundamental that something like it may occur only once in a scientist's lifetime."

OCEAN EXPLORATION in this remarkable generation has been carried on not only by scientists. Development of self-contained underwater breathing apparatus—scuba—by pioneers such as Jacques-Yves Cousteau opened the way for thousands of laymen to prowl the upper layers of the sea, breathing as freely as if above water.

Man thus entered the water world, and learned to breathe strange mixtures of oxygen and exotic gases. For extended periods, saturation dives, undersea refuges and living quarters were needed. Habitats such as Cousteau's Conshelfs in the Mediterranean and Red Seas, the U. S. Tektite in the Caribbean, and Sealabs in the Atlantic and Pacific expanded divers' ability to remain at depth for days, then weeks at a time, and provided laboratories in the deep.

As vehicles and habitats multiplied and grew more sophisticated, so also did man's eyes, ears, and other means of investigating and recording the unknowns in the seas.

Echo sounders, gravity recorders, magnetometers, heat sensors—all have been employed within the ocean and from above it, to learn more of its secrets. Photography has been joined by television, and early TV systems have now led to supersensitive solid-state devices—cameras without film—that can pick up, sharpen, and record the dimmest images in the abyss.

Sound has proved to be indispensable to science in the sea. How far can sound be detected? In 1960 a test by Lamont picked up off Bermuda a depth-charge blast detonated off Australia, 11,000 miles away. There is a deep sound channel in all the oceans, a layer varying from 2,000 to 4,000 feet down, from which sound waves cannot escape. Instead they bounce back and forth within the layer, traveling great distances as if in a huge speaking tube.

On and under the seafloor, equally incredible advances have been made. *Glomar Challenger* was limited in early years to drilling only as deep as one drill bit would last; then bit and drill pipe had to be withdrawn. The holes that struck hard rock rarely exceeded a few hundred feet.

But engineers soon overcame that problem. Guided by a sonic reflector on a steel funnel implanted in the seabed, *Challenger* now can withdraw and change a bit and put it back down the same hole, thousands of feet below. Development of a hydraulic piston corer in the past three years has enabled deeper sampling of soft sediments without disturbing them by the rotating drill pipe. The result will be far more detailed knowledge of the earth's recent geologic past.

And that is only the beginning. The next stage may use a much larger and more capable drill ship—the *Glomar Explorer*, built by Howard Hughes for the CIA to attempt to lift a Soviet submarine from the deep Pacific floor. The new drill ship will extend man's ability to probe the deep sediments of the continental margins, thought to be the storehouse of substantial oil and gas pools.

Yet in its 13½ years the Deep Sea Drilling Project has literally done little more than scratch the seafloor. To date, some 530 sites have been drilled, one for every 270,000 square miles of ocean—an area the size of Texas or the island of Borneo. "How much would we know," asks Roger Revelle, "about the Texas plains or Borneo jungle from just one hole drilled blind from a dirigible above the clouds?"

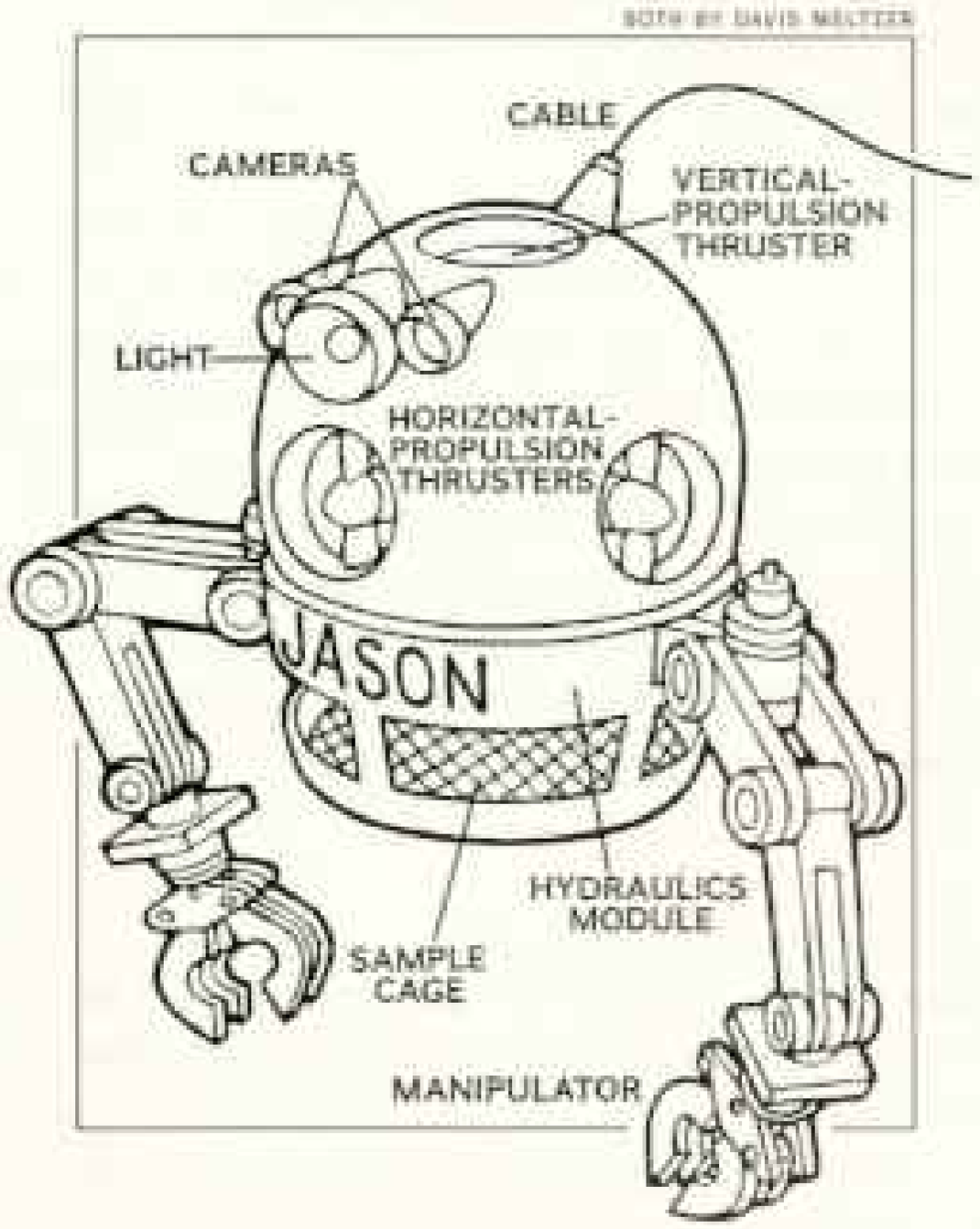
Likewise a new generation of research

A robot argosy to explore the deep sea

A PROBLEM with humans as deep-sea explorers is that half their time on duty is spent commuting to and from the bottom. With Argo and Jason, Robert D. Ballard and others at Woods Hole Oceanographic Institution and Benthos, Inc., are designing a system that will leave humans in control but above the waterline.

*During operations (**left**) a mother ship will cruise at one or two knots, navigating precisely by terrain-following multibeam sonar. From her stern a cable descends to sledlike Argo, which has two sonar systems, one forward-looking to detect obstacles (pink arc), the other side-looking (pink triangles) to investigate bottom geology. Argo's five cameras give shipboard operators a panoramic view of the bottom (green trapezoids). When scientists spot something interesting, they command Jason to deploy from Argo. Complete with lights and stereo cameras, Jason (**below**) is maneuvered for close inspection and sample collecting. Both Argo's and Jason's high-resolution images can be transmitted by satellite anywhere in the world.*

BOTH BY DAVIS MEITZER



submersibles is on the way, robots that will carry no men but, instead, their eyes and ears as well as other sensors into the depths. They will be far more efficient, say their developers, than such Model T craft as *Alvin*, which has now made more than 1,100 dives, a truly remarkable achievement.

At the Naval Ocean Systems Centers in California and Hawaii, I met the creators of unmanned exploring and working craft that propel themselves in the depths, controlled by tethers from "doghouses" lowered and powered by cables from the surface. Soon, say their builders, such craft will transmit images of what they see back over gossamer strands of glass, fiber-optic cables so fine that five miles will fit into a canister scarcely the size of a coffee can.

Bob Ballard is hard at work on such a new unmanned system. He calls it *Argo*, for the craft that Jason and the Argonauts sailed in search of the Golden Fleece. In partnership with the U. S. Navy and NASA, Woods Hole has received government funds to begin building this successor to *Alvin*.

"A pilot-scientist aboard a surface ship will sit before a bank of TV screens," Ballard envisions (facing page). "Far below him, 'flying' at the end of a cable some 100 feet above the bottom, an unmanned exploring craft will carry supersensitive imaging cameras and lights, capable of recording as much as four acres of seafloor at once."

This new deep-seeing vehicle, *Argo*, will enable the scientist to project his eyes—his mind—into the abyss in perfect safety and with virtually no time limit on his "dives." Should *Argo* spot something of interest, such as an undersea hot-water oasis or active volcanic vent, a smaller, self-propelled vehicle, *Jason*, can be sent forth to take a closer look or gather specimens of the new discovery, using claws or other samplers.

Argo will thus be an extension of the scientist's eyes and hands as he sits on the surface—or even in his laboratory thousands of miles away, watching the televised images transmitted by satellite. When he tires or goes to lunch, another can take his place.

For those who still must go down in the sea themselves, other new devices already exist or are under development. Ungainly diving suits nicknamed Jim and Wasp permit industrial divers as well as scientists to

stand and work more than a thousand feet down, breathing under one-atmosphere pressure as if at sea level. Marriages between submarine and diving suit are being developed for the oil industry as it works in deeper and deeper waters. Likewise, there are surface ships under test that may change ocean science even further.

Off Hawaii I rode the experimental ship *Kaimalino*, which the Navy terms an SSP—stable semisubmerged platform. Basically a helicopter pad on twin submerged hulls, it can race at more than 20 knots through high seas with almost no roll or pitch, offering a new breed of research and rescue craft.

Basic science goes on across the world's seas in increasingly more sophisticated ships. Soviet research vessels that ply every year to stations in the Antarctic are the size of small ocean liners.

Aircraft are increasingly used, as in the Atlantic Tropical Experiment and MONEX, the monsoon-tracking part of the current Global Weather Experiment, crisscrossing the oceans gathering data on sea-and-atmosphere interaction.

ENERGY from the oceans: The idea has fascinated men since the ancient Egyptians built tidal mills. Today, surging tides drive power plants in France, the U.S.S.R., and China. Canada and the U. S. have long studied tide potential in Passamaquoddy Bay on the Maine-New Brunswick border. Huge floating turbines, windmills, and other devices are on drawing boards to tap the power of trade winds, waves, and currents in the open sea.

And off Hawaii's Kona coast since 1979, sea trials have taken place to extract solar energy from the upper layer of the ocean.

In the tropics, sunstruck surface water may be 40°F or more warmer than water 3,000 feet below. In a process named OTEC—Ocean Thermal Energy Conversion—huge power plants would use this temperature differential to drive turbines; the electricity generated could be transmitted ashore by cables or used to extract hydrogen as fuel from seawater.

Industrial firms such as Lockheed, TRW, and others are vigorously promoting OTEC; development is funded by the Department of Energy. Though costly, OTEC could provide fuelless and unfailing power to cities and islands in tropical regions, say its proponents. Others point to unsolved problems of size, siting, and technology (the cold-water pipe for a full-scale OTEC plant, hanging half a mile deep, might be 80 feet in diameter).

And in a day of drastically curtailed federal budgets, such major projects as OTEC, deep-sea drilling, and ocean-scanning satellites now face cancellation or long delay.

IF THE OCEANS indeed are, as Law of the Sea (LOS) proponents in the United Nations proclaimed a decade ago, the "common heritage of mankind," they also face the risk of enclosure suffered by the English commons at the opening of the industrial revolution—village grazing lands divided up and fenced off for private ownership. That, say LOS advocates such as Elliot Richardson, former U. S. Ambassador to the UN, would be a common disaster for all nations.

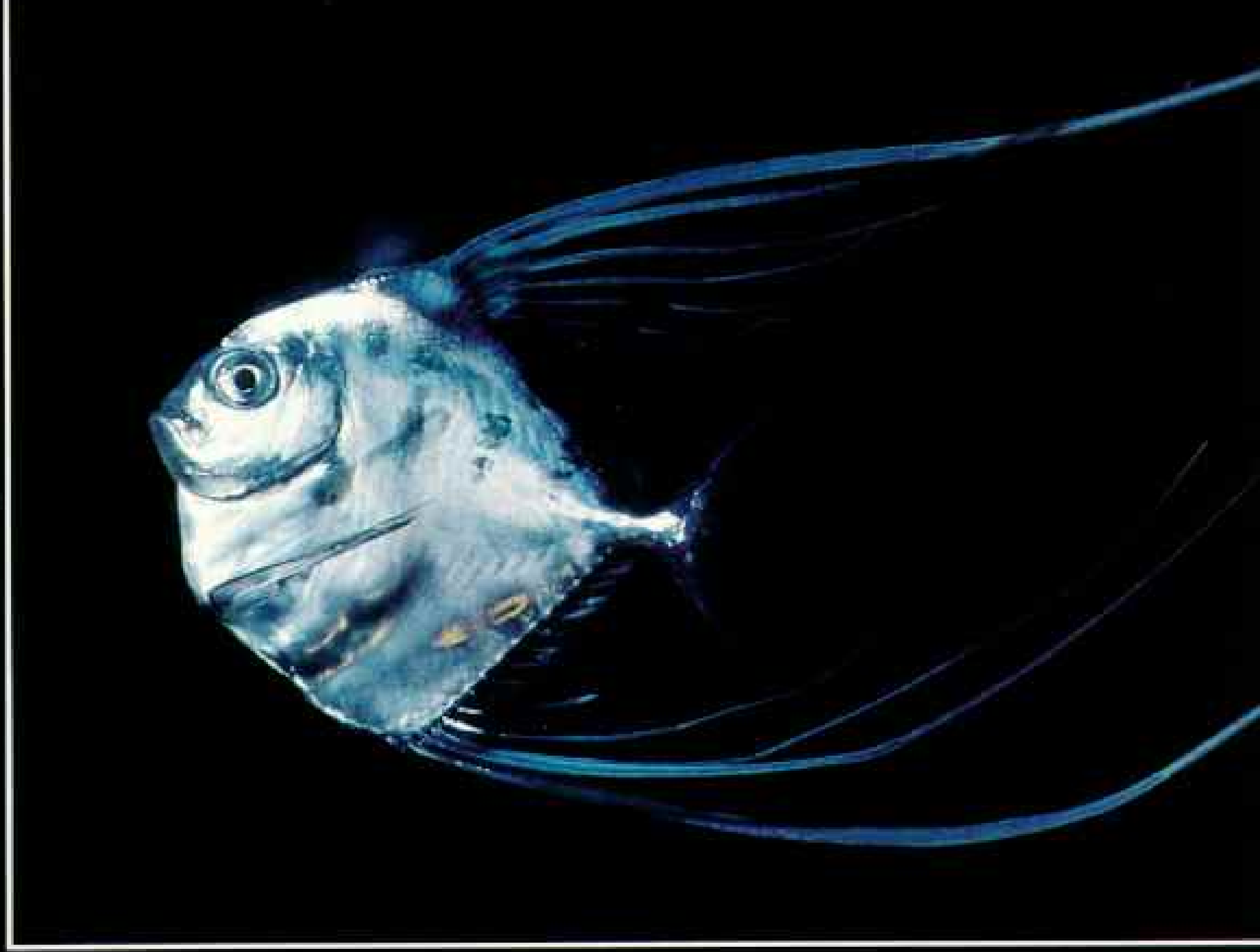
But equally important, if not more so, continued study of the seas by world scientists may bring new discoveries, exceeding even those of the past three decades.

"We may come to understand the basic interconnections between great natural phenomena," predicts James Heirtzler of Woods Hole, "seafloor spreading, movements under the earth's crust, reversals of magnetism, volcanic and earthquake activity, changes of sea level, and the major climate changes that bring on the ice ages."

Such a "unified earth theory" would rank with Einstein's theory of relativity and Darwin's on evolution among the truly great scientific advances in man's short time span on this ancient, water-mantled planet. □

***The perpetual bond** between sea and air is nowhere more intense than in a waterspout, such as this one off Florida. It is as if, for a moment, the creation of the oceans by condensation from the early atmosphere could be reversed and the two great sustainers of life be made one again.*

JOSEPH B. GOLDEN, ENVIRONMENTAL RESEARCH LABORATORIES, NOAA



IN HAWAII'S CRYSTAL SEA

A Galaxy of Life Fills the Night

WILLIAM R. CURTSINGER

OUR diving lamps are mere candles against the undersea night, yet they are spotlights for a nocturnal parade of life in a swath of the North Pacific Ocean that often seems a marine desert. Sunlight can pierce hundreds of feet into these mile-deep crystalline blue waters west of Hawaii's largest island and catch no movement. But, as in terrestrial deserts, many creatures come forward only at night.

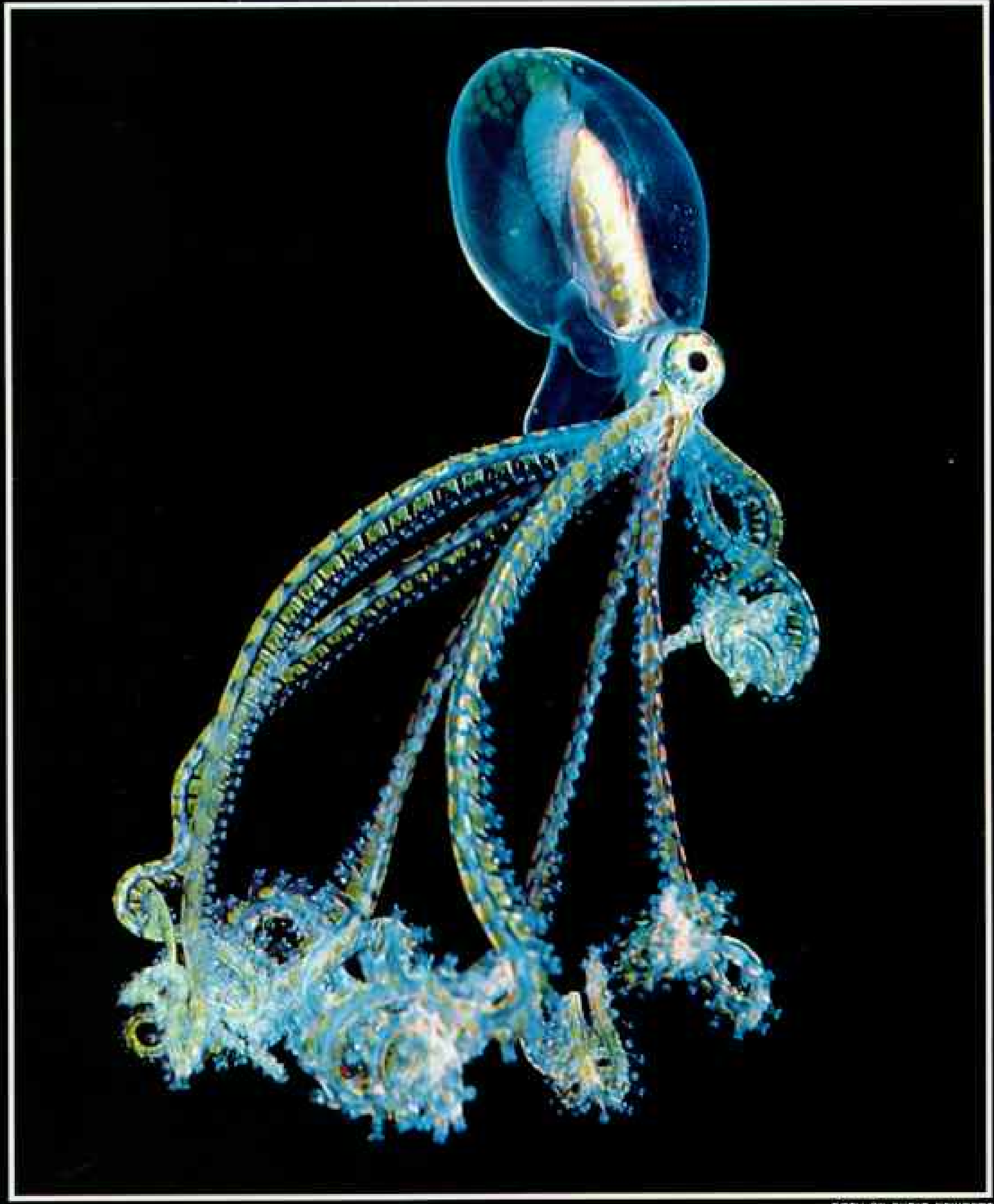
Streaming like contrails, 15-inch filaments on a three-inch baby African pompano, *Alectis ciliaris*, may discourage predators, as they did me at first, by appearing to be tentacles of a jellyfish.

By KENNETH BROWER

Photographs by WILLIAM R. CURTSINGER and CHRIS NEWBERT

CREATURES neon bright, hidden in the darkness, are unmasked by the glare of the photographers' strobes. There is always tension in night diving, but each descent guarantees astounding sights.

Phantom rider on a gossamer steed, a larval lobster sits atop a two-inch-wide jellyfish, *Pelagia noctiluca* (***right***). Some larval crustaceans hitch lifts from jellyfish. Effortless locomotion may be their aim. Or perhaps they find protection against stealthy predators, such as a young five-inch-long octopus (***below***), which alters its coloring by contracting or expanding chromatophores—pigment sacs. Light reflects off its internal organs, shielded by a bulbous transparent mantle.



BOTH BY CHRIS NEWBERT

NIGHT WATCH in the Pacific means preparing for the expected—sharks—and awaiting the unknown. Coral reefs and kelp forests continually lure marine observers, but the dynamics of life in the open sea remain largely unchronicled.

For six weeks we dived almost nightly on the lee side of the island of Hawaii, whose wind-blocking mountains rendered 300 square miles of sea calm enough for travel in a small boat. Three to ten miles offshore we stilled the engine and let the current determine our course.

Our homemade antishark cage of plastic plumbing pipe and Plexiglas dangled 28 feet below. Designed to hold the three of us, it proved its value when our maneuvers excited passing sharks. But generally we spent little time in the cage. As we roamed between the surface and 150 feet below, the marine desert came to life.

A great vertical migration begins in the sea at dusk. Tiny zooplankton rise to feed, and the food chain follows. Larval fish, such as this one-inch scorpionfish, *Taenianotus triacanthus*, are among the hungry predators.

The drama plays at a frantic pace beneath two automobile headlights attached to our cage. The beams are homing beacons to us and magnets to sea life. There, shrimplike amphipods and krill dance as furiously as insects under a streetlamp. Larval fish dart toward them, like ghostly salmon leaping up waterfalls of light.

A desert has become a jungle.

CHRIS SEASICK

SEEMINGLY DRAWN from a page of a medieval bestiary, the pearlfish in its larval incarnation is one of the most enchanting and baffling creatures we encountered.

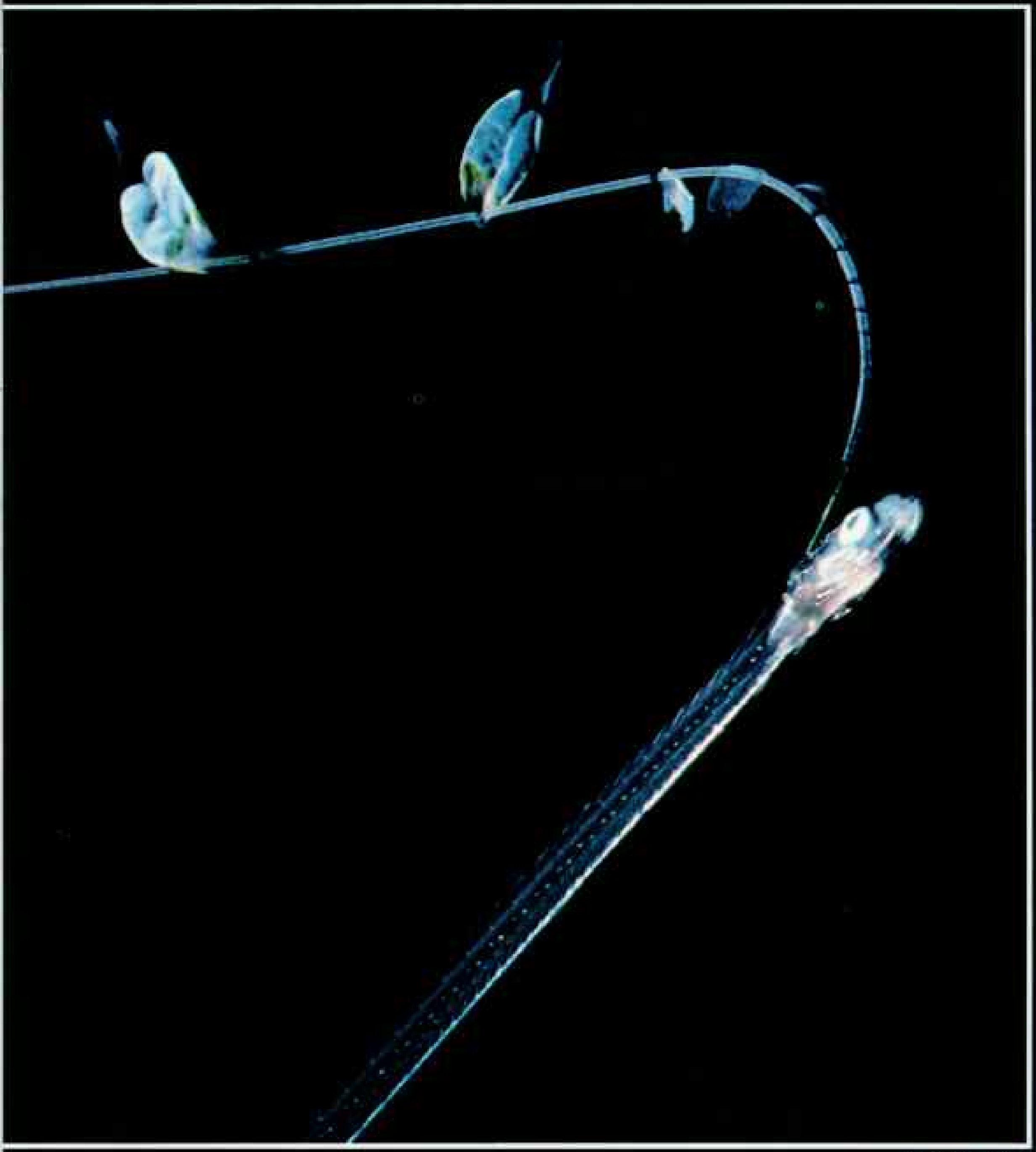
Shining chromatophores stud the narrow ten-inch body, lower right. Ornaments of unknown function flutter like willow leaves on an extended dorsal-fin ray, exceeding the body length. Few live specimens of *Onuxodon margaritiferae* have been available for study, and none bear these ornaments, which probably break off during capture.

With our photographs and observations of larval pearlfish in the wild, marine biologists hope to enhance theories of the filament's use. Like a weather vane, it may help the fish orient

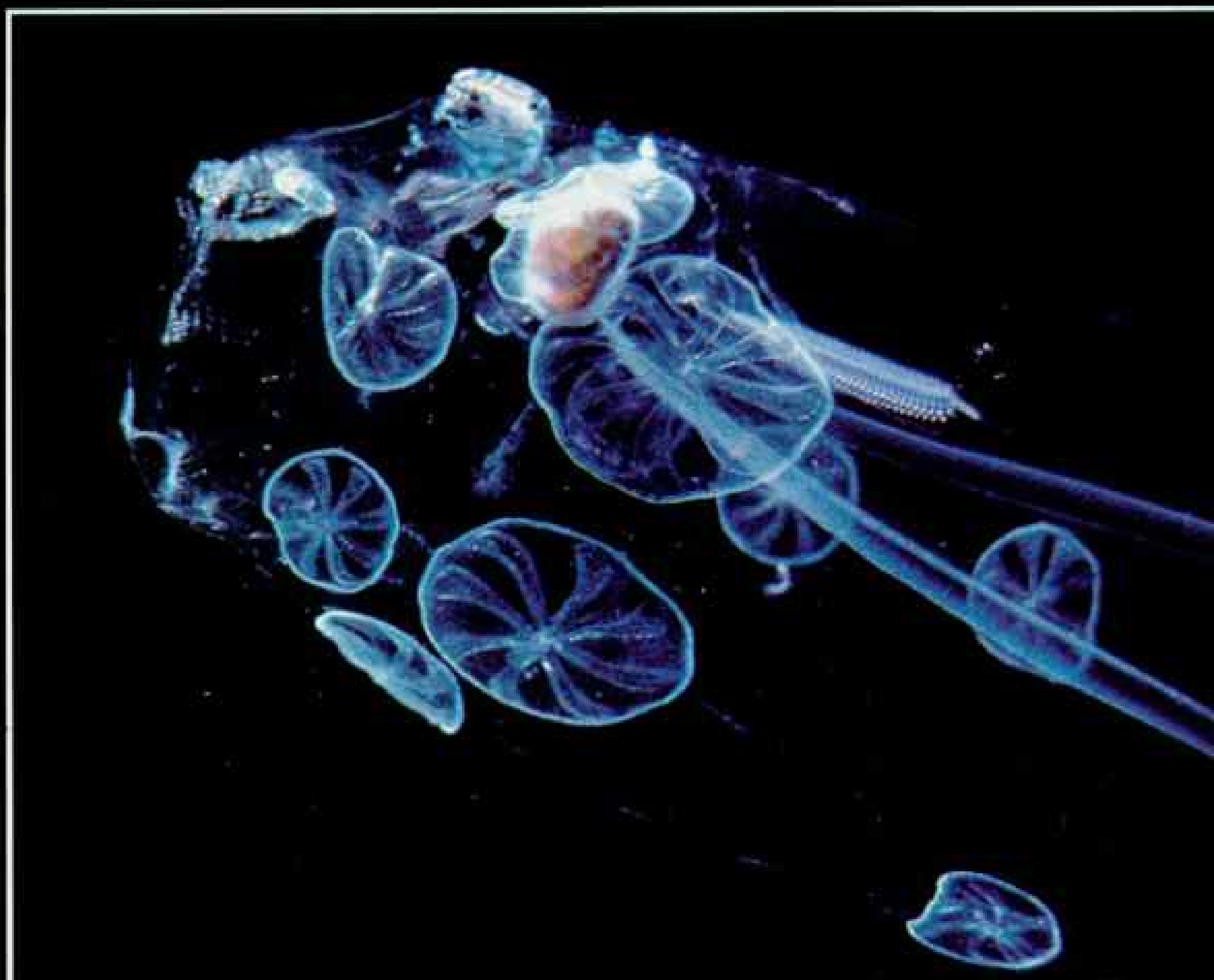
toward the current to find food.

This headgear is lost in adults, most of which live in shallower water, tucked inside the body cavities of sea cucumbers, starfish, or shells of live oysters.

The open ocean around reefs is a nursery for pearlfish and other creatures that set eggs adrift where hatchlings can develop in the more stable oceanic environment.



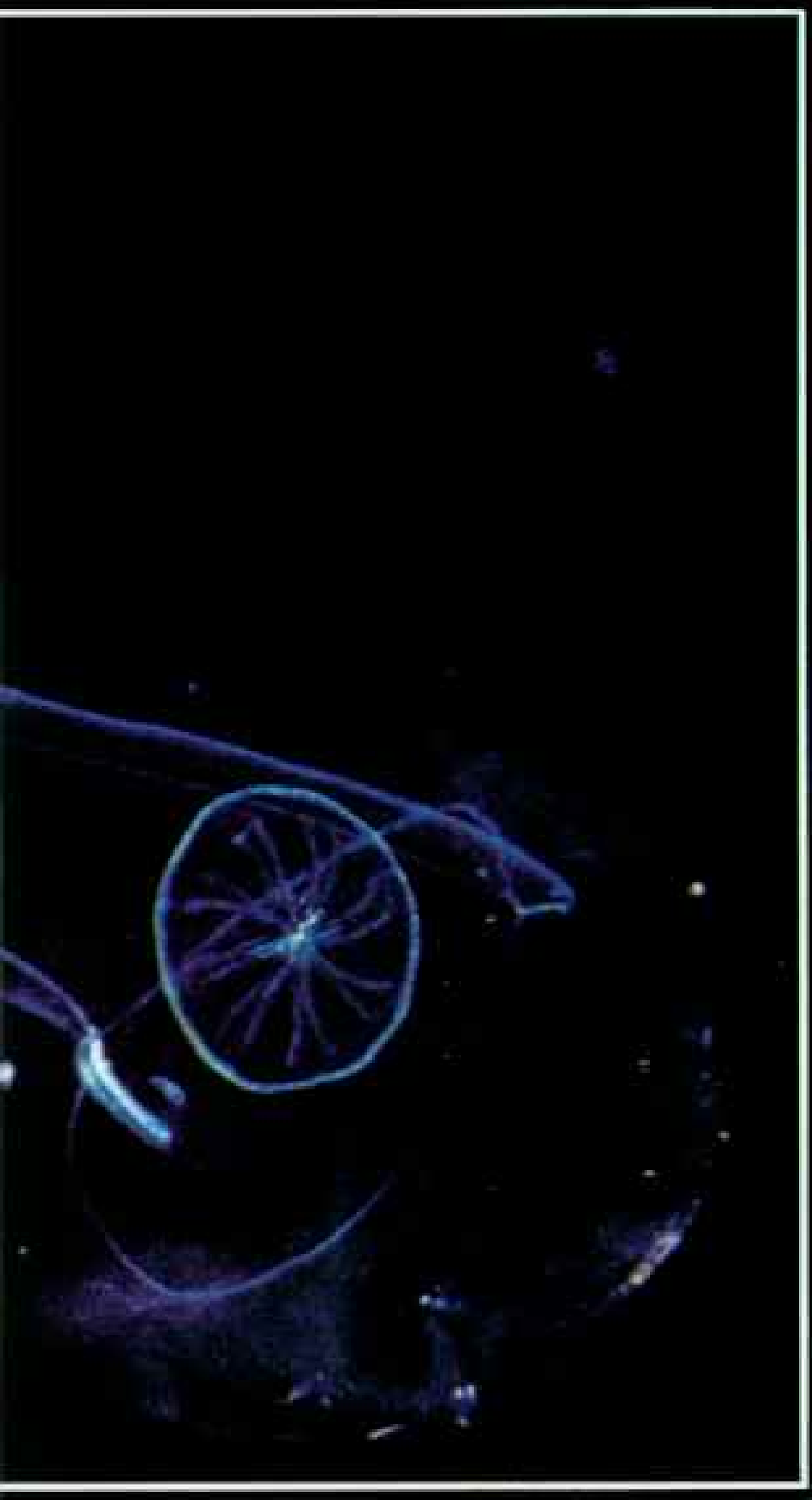
WILLIAM H. CURTSINGER

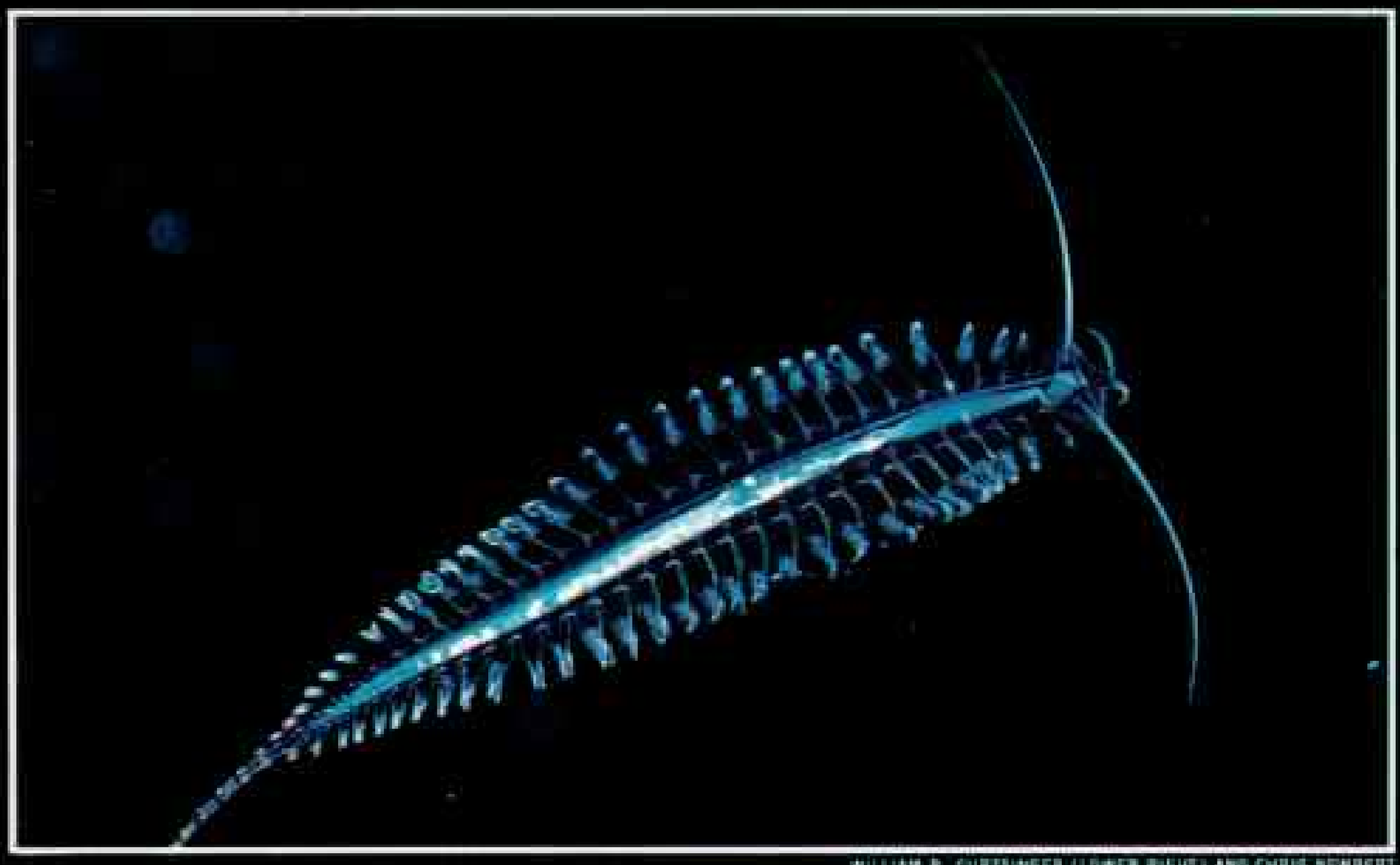


EATEN ALIVE: A three-inch-long salp, *Salpa cylindrica* (**above**), slowly loses gelatinous body tissue to ctenophores that here, flattened, resemble lemon slices. As the salp draws water through its barrel-shaped body for locomotion, it harvests phytoplankton with a net supported by a long branchial bar. A chain of baby salps floats like a corncob above the bar.

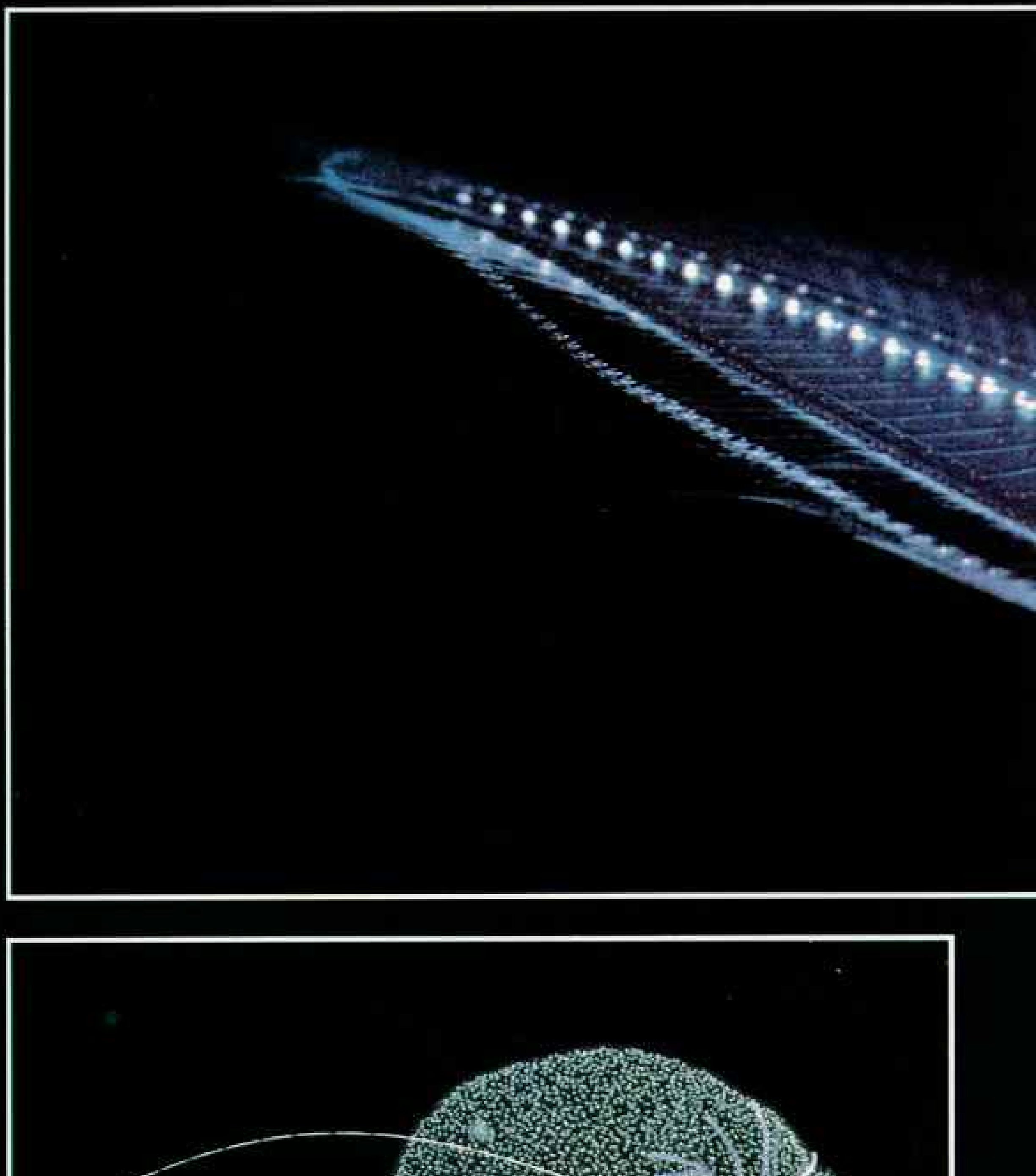
A female amphipod, *Phronima sedentaria* (**above right**), devoured a salp's internal organs and saved the casing to serve as an incubator and baby carriage for her soon-to-be-hatched larvae.

Food glimmers in the digestive tract of a polychaete worm, *Tomopteris*, here life-size (**right**). The worm stilled its paddle-shaped appendages when tapped by Bill Curtsinger's camera, and released a camouflaging puff of golden dust. Then Bill touched the body and was surprised by what felt like an electric shock, unknown in the little-studied worm. Whether it was an electric charge or a numbing toxin is not known. But that is the allure of our work: raising questions.





WILLIAM K. CURTSINGER (LOWER RIGHT) AND CHRIS REMBERT



CHRIS NEWBERT (ABOVE) AND WILLIAM R. CURTSINGER

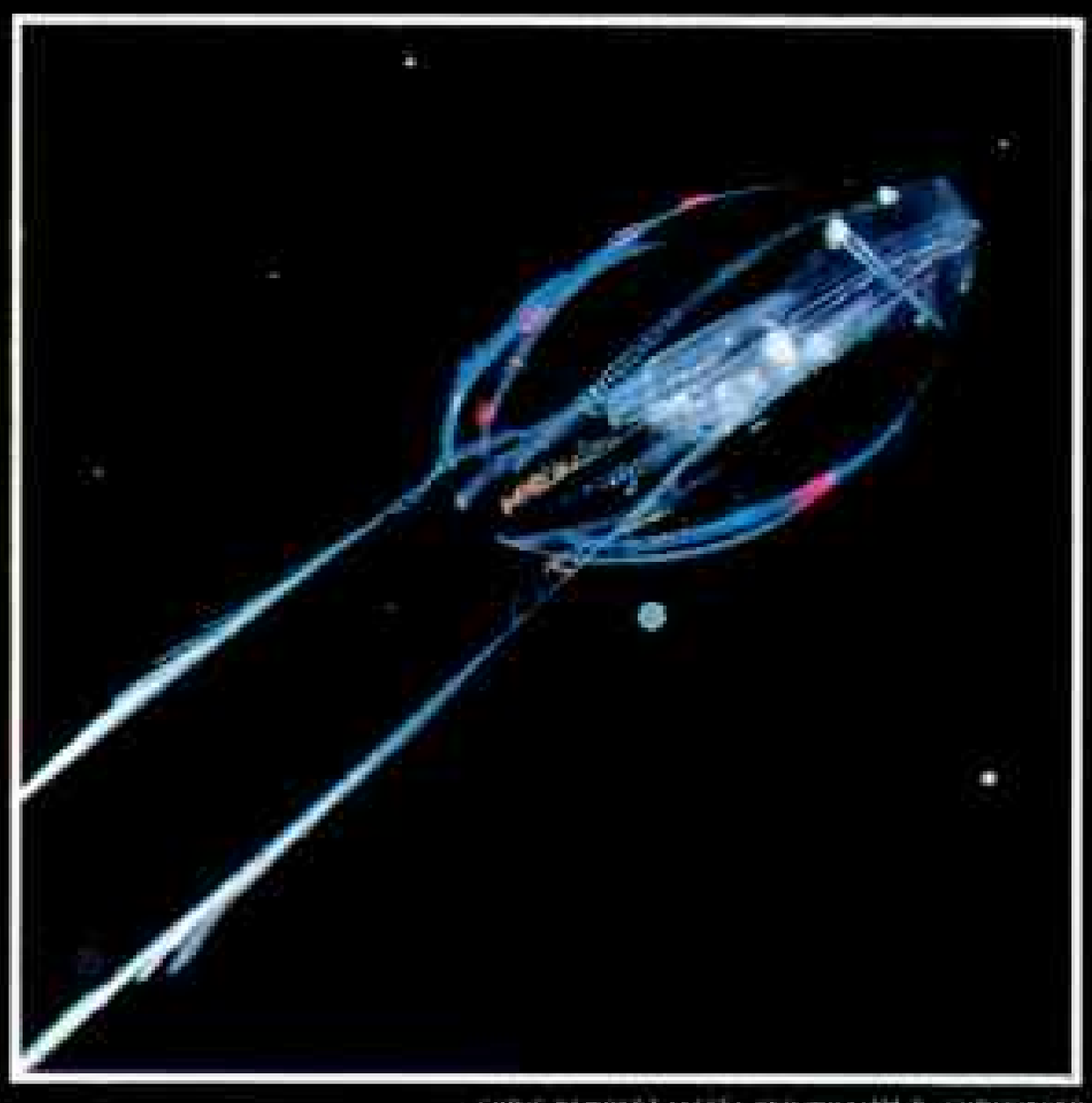
SPELLBOUND BY LIGHT, a left-eyed flounder (***above***) was easily mesmerized momentarily. Potato-chip thin, it could fit on a half-dollar at this stage of its metamorphosis, when the right eye migrates to the other side of its head to prepare the fish for bottom feeding.

Not all sea dwellers share the flounder's fascination with light, but we learned that it was futile to dive when the moon rose full and early. Our lamps could not compete with a sequined sea.

A larval shrimp takes a floating carpet ride on a radiolarian, *Rhaphidozoum*, two and a half inches in diameter (***left***). Each dot on the jelly disk marks a single animal equipped with tiny projections that trap food. Algae lend color to this radiolarian colony, borne on a current 30 feet below the surface.

Larval crustaceans swim in a surface pool of life attracted by the aura of a headlight rigged aboard our boat. Hoisted in our dip net, miniature crystal likenesses of mature crabs display adult-size tempers, snapping claws that look like blown-glass scissors.

Transparency helps larval creatures hide from predators and may prevent absorption of ultraviolet sunlight.



CHRIS NEMBERT (LEFT) AND WILLIAM R. LIEBSINGER

RHINESTONE COWBOY of the ocean range, the ctenophore *Hormiphora palmata* (**above**) lassos its prey—small zooplankton—with tentacles saddled with adhesive cells. Spectral colors ripple across its inch-long body as the rows of beating cilia that propel it fragment light like prisms.

As fragile and whimsical as a dream, the siphonophore *Forskalia* (**left**)—a member of the phylum that includes jellyfish—develops into a conglomerate of parts that seem to be borrowed from several members of the phylum at varying stages of their growth. Its feeding units lie near the ends of stinging tentacles. Pulsing locomotion units dot the transparent two-inch domed body, stabilized by the gas bubble near the crown.

These are the visions that made night diving our addiction. We suspended fear—and sometimes belief—as we gazed at creatures whose beauty, or very existence, we had never imagined. □

REPORT TO
THE MEMBERS

It's Been a Banner Year!

By GILBERT M. GROSVENOR
PRESIDENT, NATIONAL GEOGRAPHIC SOCIETY

Terraces of our new building

I RECENTLY had the pleasure of breaking ground for a new Society building at our headquarters in Washington, D. C. As I stood with the ceremonial shovel in hand, many memories—and hopes—crowded my mind.

Ninety-four marvelous years of achievements form the record of the Society—and surely many lie ahead. Having relinquished my ten-year stewardship as Editor of the magazine for that of President of the Society 16 months ago, I view our mission with slightly different eyes, taking in the widening horizon of our many educational activities. What I see excites me, and I wish to share with you some of the highlights of this year at National Geographic.

First of all, the Society has steadily grown. With 10,850,000 members in more than 180 countries, membership is more than a third larger today than it was ten years ago. Also, our commitment to reach young people, both at home and in the school curriculum, has burgeoned. The staff has grown, too, as we keep pace with expanding projects. Hence the new building, designed to meet our needs until 2030.

And my second impression of 1981 is that National Geographic's rigorous standards have never been more vigorously pursued in our 94-year history.

TV Programs Win Many Awards

Our television Specials, now in their 16th year, are among the most popular on the Public Broadcasting Service. Carried by nine out of ten PBS stations, the Specials make up nearly half of the 25 top-rated PBS telecasts. Last year's series won not only four Emmys, TV's highest honor, but also a George Foster Peabody Award for "unsurpassed excellence in documentaries."

Next year's series, once again underwritten by a generous grant from the Gulf Oil Corporation and coproduced with WQED/Pittsburgh, promises an equally excellent season: an invigorating dip into the truth about sharks; a spectacular new look at the

ARCHITECTURAL RENDERING FROM INTERFACE

will range between Hubbard Memorial Hall, left, and the marble high rise added in 1964.

great treasures of Egypt; a story of man's successful coexistence with polar bears; and a journey on Britain's River Thames.

To keep one of our most praised publications up-to-date, we published a completely revised and enlarged fifth edition of the *National Geographic Atlas of the World* in October. The new atlas places the earth in a galactic context. There are charts of the solar system, the visible stars, maps of the ocean floors and of the moon, and illustrations of the atmosphere, magnetosphere, plate tectonics, and climate.

The politics and economy of each nation have been updated, and new profiles have been written for each state in the Union and each province of Canada. The atlas offers a realistic look at the world; new maps show the distribution of global resources, clues to international wealth and poverty. Annual supplements will be sent to all owners until the next full revision is issued.

The energy predicament in the United States concerned NATIONAL GEOGRAPHIC editors so much that last year they prepared an unprecedented special issue summarizing the major problems. The report went to members as a "13th issue" in February. Demand for the 115-page issue was so great that more than 220,000 extra copies were distributed. Indeed, more people have written to us about the Energy issue than about any other article, book, or television program we have ever produced. Most agreed with Governor George R. Ariyoshi of Hawaii: "It is one of the finest assessments of the world's energy situation I have seen."

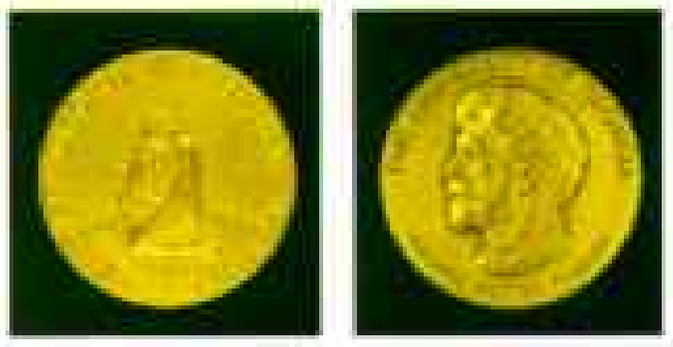
In other issues this year the magazine has sharpened its coverage of some equally complex subjects through what the magazine's new Editor, Wilbur E. Garrett, describes as a "mini-book" approach to the events.

"When something like Mount St. Helens takes place, we want to show our readers the whole picture," he says. "Rather than chase fast-breaking news like the daily media, we try to make our coverage as complete and thoughtful as possible. Occasionally, as in

In the tradition of excellence

- The Emmy is television's top award—given by the National Academy of Television Arts and Sciences (***above***). National Geographic's Television division won four Emmys for three of the 1980 Specials, "Dive to the Edge of Creation," "Mysteries of the Mind," and "The Invisible World."
- The University of Georgia's George Foster Peabody Award (***medal at upper right***), also for our 1980 television season.
- Blue Ribbons at the American Film Festival in New York for "Dive to the Edge of Creation" and "World Within Worlds," a film for classroom use, released by our Educational Films division.
- The CINE Golden Eagle from the Council on International Nontheatrical Events for Educational Films' "Portrait of a Coal Miner."
- 1980 Publication Award from the Geographic Society of Chicago for *Our Universe*, published by Book Service.
- Recognition from the Children's Book Council, Inc., for three books from the Special Publications and School Services division—*Wildlife Alert! The Struggle to Survive*, *Secrets from the Past*, and *The Mysterious Undersea World*.
- Four EDPRESS awards in 1980 and one in 1981, for excellence in educational journalism, to WORLD, our magazine for children.

- The Gold ECHO award (***above left***) from the Direct Mail/Marketing Association, Inc., received by the Promotion and Educational Services division.
- Art Directors Club of Metropolitan Washington's Silver Medal (***above right***) for the Mount St. Helens issue of the GEOGRAPHIC, January 1981, one of 22 design awards from the group for our entries.
- 1981 Engineering Public Service Award from the Washington (State) Society of Professional Engineers for the Energy issue and the January 1981 article on Mount St. Helens.
- Boston's Museum of Science's Bradford Washburn Award (***below left***) to Science Editor Kenneth F. Weaver for being a "gifted editor and communicator for science."



- 1980 Magazine Photographer of the Year award (***below***) to GEOGRAPHIC contract photographer Jim Brandenburg in a competition sponsored by the University of Missouri School of Journalism, the National Press Photographers Association, and Nikon Inc. Several other GEOGRAPHIC photographers won in various categories, and Illustrations Editor Bruce A. McElfresh was cited for work on the Mount St. Helens article.

ALL BY ROBERT S. OAKES, NGS

- The 38th annual White House News Photographers' Association contest brought 17 awards to NATIONAL GEOGRAPHIC. First-place winners were Steve Raymer, George F. Mobley, Bruce Dale, and Cotton Coulson.

NATIONAL GEOGRAPHIC SOCIETY

WASHINGTON, D.C.

Organized "for the increase and diffusion of geographic knowledge"

GILBERT HOVEY GROSVENOR
Editor, 1899-1954; President, 1920-1954
Chairman of the Board, 1954-1966

THE NATIONAL GEOGRAPHIC SOCIETY is chartered in Washington, D.C., in accordance with the laws of the United States, as a nonprofit scientific and educational organization. Since 1890 the Society has supported more than 2,000 explorations and research projects, adding immeasurably to man's knowledge of earth, sea, and sky. It diffuses this knowledge through its monthly journal, NATIONAL GEOGRAPHIC; its books, globes, atlases, filmstrips, and educational films; *National Geographic WORLD*, a magazine for children age 8 and older; information services; technical reports; exhibits in Explorers Hall; and television.

Will it drive everyone back to the drawing board?

When we first introduced the Honda Accord, we thought it was the perfect car for the time.

Others must have thought so, too. Because everyone tried to improve it. Now somebody has.

For 1982, Honda introduces the new Accord. Still simply a Honda, but also a newly styled car.

The new Accord is roomier inside and longer outside. It rides smoother and handles better. The gas mileage is better, too.

With the 5-speed, a gallon of gas takes you an EPA estimated 30 miles, an estimated 41 miles highway.

Use 30 mpg for comparison. Your mileage may vary according to weather, speed or length of trip. California figures will be lower. And you can expect actual highway mileage to be less.

You can also expect the total economy that has made Honda cars famous throughout the years.

And the new Accord still has Honda's proven front-wheel drive and transverse-mounted engine.

One more thing hasn't changed either. Honda quality.

We continually go back to the drawing board. To stay ahead. While others go back to catch up.

HONDA

We make it simple.

"Now you know
why I helped decorate
the tree."

Nothing else feels like real gold.
Nothing else makes any moment so precious.

Give her the gleaming, elegant, enduring gift she will treasure all of her life.
KARAT GOLD JEWELRY

For more information about Karat Gold Jewelry or the specific jewelry pictured here,
write to Jewelry Information, International Gold Corp. Ltd., 645 Fifth Avenue, New York, N.Y. 10022.

Is this country in the autumn of its time?

There are those who say this country is in the autumn of its time. That we have lost our pride, and quality no longer is a way of life.

Whirlpool disagrees.

As a maker of home appliances, we believe that pride and quality are so much a part of this country's heritage we must be true to them in everything we make.

Whirlpool believes that this is not the onset of winter but the advent of spring.

A new beginning, where quality will once again become a way of life for everyone.

Whirlpool
Home Appliances

For the cost of a few extra rolls of film you can own the choice of professionals, instead of the choice of amateurs.

*Cost comparison based on purchase of 2 to 5 rolls of 36 exposure color print film, plus processing.

Nikons are used by more professional photographers than all other 35mm cameras combined.

But you don't have to be a pro to own a Nikon.

For not much more than it would cost to buy one of those cameras amateurs buy, you can own the Nikon FE. A camera which many professionals buy because it's compact, yet durable.

The Nikon FE—like our top-of-the-line camera—is simple to operate. It features aperture priority automation. Which means you set the f-stop and the camera automatically selects the correct shutter speed. Shutter speeds are electronically controlled and continuously variable from 1/1000th to 8 full seconds.

If you choose to override the automation, just turn a dial and you'll be in complete manual control. Which means you can exercise your creativity by intentionally overexposing, underexposing or double-exposing your shots.

The FE has other features professionals have come to value about Nikon. Things like true center-weighted metering for exposure accuracy. A memory lock feature that helps you get perfect exposures, even under back-lit conditions. Interchangeable viewfinder screens. And a solid, all-metal body for unsurpassed ruggedness and reliability.

And when it comes to lenses, Nikon offers what many professionals regard as the finest system in the world. There are over 60 Nikon lenses in all. Our world-renowned Nikkor lenses range from a 6mm fisheye to a 2000mm super-telephoto. Or, if you prefer, you can choose one of Nikon's superb, but inexpensive, Series E lenses.

So why spend your money on a 35mm camera that's famous among amateurs? When for the cost of a few extra rolls of film,* you can have something in common with the pros?

Nikon

We take the world's greatest pictures.™

DODGE MINI RAM. MORE MILEAGE, RANGE AND SEATS THAN VW VANAGON FOR $1325 LESS.

Who moves more people than VW for less money? It's Ram Tough Dodge's new Mini Ram Wagon.

Compare Dodge Mini Ram 250 to VW Vanagon — passenger seating, gasoline mileage, fuel capacity and range, horsepower and rear loading area. Mini Ram gives you more.

Then compare standard features like power steering and factory-installed options like air conditioning and your choice of 6 sound systems: all available in Mini Ram. Not in Vanagon.

Now compare price. Mini Ram costs $1,325 less than Vanagon. For panel-side van buyers, there's a Dodge Van with the same performance, efficiency and interior dimensions as Mini Ram Wagon at a price VW hasn't seen in years —just $6,928.*

Underneath it all, Mini Ram is a Ram Tough Dodge Wagon. With the best rust protection of all wagons. There's 100% electrocoating, plus 370 sq. ft. of galvanized steel in critical areas . . . compared to VW's 4 sq. ft.

New Dodge Mini Ram Wagon. It does more than VW Vanagon and it does it for less. As a pure people mover, it just might be the best buy on the road today.

Here's how Mini Ram beats Vanagon

	Dodge Mini Ram Wagon 250	VW Vanagon
Sticker Price (MSRP)*	**$9,365.00***	**$10,690.00***
EPA EST. MPG	19 MPG**	17 MPG**
Horsepower	98	62
Passenger Seating	8	7
Overall Length	178.9"	179.9"
Wheelbase	109.6"	95.6"
Fuel Capacity	36 gal.	15.9 gal.
Est. EPA Range*	684 miles**	270 miles**
Side Door Width	49"	42"
Removable Rear Seat	Yes	No
Power Steering	Standard	Not Available
Color-Keyed Carpeting	Standard	$410 with opt. pkg.
Factory Installed Air Conditioning	Option	Not Available

DODGE TRUCKS ARE RAM TOUGH

*Sticker price comparison, excluding title, taxes and destination charges, unadjusted for different levels of standard equipment. Whitewall tires $85 extra. Prices and specifications as of October 1, 1981.

**Use these numbers for comparison. Your mileage and range may differ depending on speed, distance and weather. Calif. est. lower.

Members Forum

Congratulations on Members Forum. This is what was missing.

Carlos Sikes
Long Island City, New York

I am delighted.

Sue S. McCann
Arnold, Maryland

The timely, meaty articles on world trouble spots and the Members Forum are excellent, and evidence of the vitality of your organization.

John Simmons
University of Kansas
Lawrence, Kansas

I heartily approve of NATIONAL GEOGRAPHIC publishing the onions as well as the orchids.

Dennis J. Shank
Lawrence, Massachusetts

The first batch of communications is so severely edited and condensed that the flavor is lost.

Edward H. Devoe
Frankenmuth, Michigan

It would seriously restrict the number and variety of letters if we were to publish our members' thoughts in their entirety.

Over the years I've thought that a Letters to the Editor column in NATIONAL GEOGRAPHIC would be an asset to the journal.

Well . . . I've just read the first one.

Please, no!

I've never read such drivel.

Name withheld by request
Baltimore, Maryland

Response to this new feature has been overwhelmingly favorable. Of the hundreds of letters addressed to Members Forum, there have been few complaints.

VIETNAMESE FISHERMEN

The Vietnamese described in your excellent September article are in the finest tradition of minority groups that preceded them and made our country the great nation it is today. They have clearly earned their place in America!

Bill Mella
Los Angeles, California

A land that is itself stricken with drought, declining water tables, and diminishing resources is in

no position to continue accepting immigrants and/or refugees. Emma Lazarus's welcome ended when Ellis Island was dismantled in 1954.

Aza Mahlet
Carpinteria, California

Thank you for the story of the Vietnamese fishermen. I was so touched I almost cried. I came here in 1975 by myself with nothing, couldn't even speak English. Now I have graduated from college and joined the American work force.

Ngoan-van-Vo
Burton, Ohio

Your September cover of a Vietnamese child. . . . Seldom do sheer beauty and innocence combine to so charm the beholder.

Henry J. Dieringer
Portland, Oregon

PAST PHOTOS MAKE FUTURE ART

You might be interested in one rather widespread use of your magazine. A short while ago I was, along with a younger illustrator, judging a science-fiction art show. He pointed at a painted mountain on an imaginary Venus and said, "NATIONAL GEOGRAPHIC, 1967." "Yeah," I said, "June." All of us in the trade have made such frequent references to the GEOGRAPHIC in the course of our labors that we recognize the photos as old friends. If there's a moral, it must be: "If you must swipe a mountain, swipe it from an obscure source."

Thanks again.

Jack Gaughan
Rifton, New York

Moving mountains to Venus, unfortunately, does not remove them from the purview of copyright laws. Reproduction in art of NATIONAL GEOGRAPHIC photographs—or those from any copyrighted publication—is a violation of such law. Portraits of people may also be an invasion of privacy. We realize, of course, that inspiration springs from many sources.

NEW YORK

What a better way of saying I ♡ New York!

Linda Peppelman
Newtown, Pennsylvania

Why was there no map with the story on Manhattan in the September issue? Perhaps to you who are familiar with New York City a map seems unnecessary, but to millions of us who have never been there, a map is as essential to our enjoyment of an article about Manhattan as it is to a story on Helsinki or Bombay.

Neila Tillman
Lansing, Michigan

Because Manhattan is such a large subject to condense into one 30-page article, we chose in our picture coverage to convey an impression of the city rather than to attempt to show all its important features. This would have been impossible. In that context a detailed map of the city seemed inappropriate.

SILVER

You state that silver prevents sparks that could set off the shuttle's explosive liquid-oxygen propellant. I'm sure that Mr. Boraiko meant to write that it is liquid hydrogen that is the highly explosive propellant used in the shuttle main engines.

Eric G. Lemmon
Lompoc, California

True, liquid oxygen by itself cannot explode. We should have said, "prevent sparks that could set off a fire in the liquid-oxygen pump."

I was intrigued to learn that Miguel de Cervantes was responsible for the aphorism, "All is not gold that glisters."

I had always been under the impression that it was the work of William Shakespeare, from *The Merchant of Venice*, Act 2, Scene 7.

J. Robert Johnson
Los Altos Hills, California

This common proverb is so apt that Chaucer, among others, used it before Cervantes and Shakespeare. The Bard admits the phrase was well known when he follows it with, "Often have you heard that told." The original author would be hard to pin down.

Readers of the well-written article on silver may be interested to know that a taller, if not wider, silver object than the maharaja's water jug was designed by William Codman and made by the Gorham Manufacturing Company in 1899 for presentation to the "Hero of Manila," Adm. George Dewey. This magnificent loving cup is seven feet nine inches high!

Mrs. Dean A. Fales, Jr.
Kennebunkport, Maine

TAIWAN

Why hasn't Taiwan been presented? It would make an excellent topic.

Ken P. Lee
Erie, Pennsylvania

An article on Taiwan will be published in next month's issue.

RESEARCH GRANTS

When I was younger, I thought of the Society as an organization that put out a very readable publication of great educational value. Now that I'm

Still looking for the perfect Christmas gift?

Twelve issues Just $13.50*

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form to present gift memberships to
family and friends. Or write to:
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Washington, D. C. 20013

*Postage rates vary outside United States
as listed on the attached order form.

a little more mature, I realize that the Society also supports varied scientific research projects that would probably get lost in the grant-support shuffle otherwise. I want to congratulate you for having so quietly, and so effectively, plugged a series of important holes in support of modern science.

Arthur J. Boucot
Professor of Geology and Zoology
Oregon State University
Corvallis, Oregon

The National Geographic Society contributes two and a half million dollars a year to some 150 research projects that include early-man exploration in Africa, new deep-sea technology, and photographic surveys of the heavens.

A WALK ACROSS AMERICA

Could you tell me if Peter Jenkins's second book has been published?

Clay Marquis
Pleasant Hill, Missouri

According to the publisher, William Morrow & Company, Inc., Mr. Jenkins's book Walk West *should now be in your bookstore.*

BIRD RECORD

I really enjoyed the issue that put the little plastic record in about whales. I wish you would have an insert record of birds.

Eileen Laverie
Osgoode, Ontario

The National Geographic Society's book Song and Garden Birds of North America, *available for $11.95, contains records of birdsongs.*

OMAN

I am so disappointed about Oman. The picture on page 345 is not an Omani picture. We do not have that kind of dance. The population is not 890,000. It is approximately 1.5 million.

Ali A. Al-Lamki
Bonn, West Germany

The dancers at the festival honoring the sultan in the capital of Muscat are from an area shared by Oman and the United Arab Emirates. Despite some estimates of a population of 1.5 million, most demographers agree with our figure.

Letters should be addressed to ***Members Forum,*** *National Geographic Magazine, Box 37448, Washington, D.C. 20013, and should include sender's address and telephone number. Not all letters can be used. Those that are will often be edited and excerpted.*

GIVE HIM HIS OWN SET OF KEYS.

time, and is good for years and years and years of hard driving. (That's something for you to think about, too!)

The fact is, there is no other portable like a Smith-Corona. It has a unique cartridge system, so you can type on fabric or film ribbon, in black or in colors.

And you can correct mistakes two different ways, including our brand-new Lift-Rite,™ that actually *lifts* mistakes clean off the page!

Type on a Smith-Corona. Its letters march smoothly, evenly, cleanly across the page. Listen to it. It sounds solid and professional. And you can count on a Smith-Corona. It will be around years from now, giving the same fine performance.

It's easy for a typewriter to make a good first impression. But a Smith-Corona makes the kind of impression that your kid will be writing home about, long after he's finished school.

Smith-Corona

Find out how Beech can deliver more than an airplane to solve your company's travel problems.

It's getting harder and harder to go fewer and fewer places on the airlines.

And company cars show you more road than results.

Business travel is a bigger problem today than ever before. But there is a solution.

Your own Beechcraft can solve your travel problems practically and profitably. You plan your travel around business, not vice versa.

You fly direct to all the destinations the airlines serve plus literally thousands that they don't.

And your most valuable resource, qualified management, can be there, when and where you need them.

The benefits are obvious. But even more than solving travel problems, Beech delivers an organization dedicated to simplifying airplane ownership and operation.

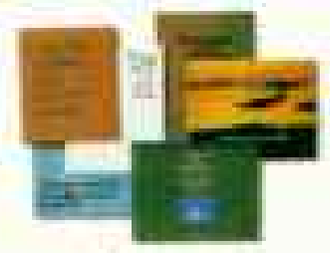
It all starts with your free *Management Guide*. It's loaded with information to help you make a decision about a Beechcraft. A book of facts. A Capital Recovery Guide to show you the net capital cost of ownership. And much more.

It extends through the network of Beechcraft Aviation Centers, staffed with aviation professionals. They'll provide anything you need, from an airplane, to a qualified pilot, to complete maintenance support.

But the ultimate simplicity of ownership comes from the incomparable quality of a Beechcraft. Quality that translates into reliable operation, fuel efficiency, lasting value and a ready resale market.

Want to find out more? It's simple.

Send for your free 1981 kit.



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The Pressurized Beechcraft Duke carries six in cabin class comfort and quiet at over 280 mph.

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So accurate you may have to reset it only once this year. Thin, sleek, more beautiful than any watch you've owned before. Built and priced in the Timex tradition. 39 styles for men and women from $39.95 to $61.95, suggested retail prices.

TIMEX

We make technology beautiful.

Some insist coal is good. Some insist coal is bad.
We insist it's not that black or white.

Those who insist that coal is good point out that we have over 200 billion tons of economically recoverable coal in this country—enough to last us for at least three centuries at current consumption rates.

And, they further point out, although that represents 90% of our domestic energy resources, coal currently supplies less than 20% of our energy production.

It's true, that with greater usage, coal could give us as much as one half of the new energy we'll need between now and the year 2000—enough to help loosen the dangerous ties that bind us to expensive and insecure foreign oil.

But those who insist that coal is bad point to abandoned mines which scar the landscape and allow acid water to seep into streams.

And to the fact that coal contains ash and sulfur which, if not controlled, can pollute the air when burned.

Still, we at Atlantic Richfield's ARCO Coal Company believe that today the advantages of coal outweigh its disadvantages. And so do the many Americans who have invested with us.

That's because these days we have extremely tough environmental laws.

Laws that require the restoration of mined lands and the protection of air and water resources. Laws that ensure that coal mine areas are properly restored and that newly constructed or converted power plants reduce air pollution to protect health and welfare.

Of course, environmental controls are expensive. But they are a worthwhile investment when you consider that the cost of using coal is still less than half of the current cost of using oil.

And when you consider that coal can also be converted into transportation fuels such as gasoline and diesel fuel—reducing even more our dependence on foreign oil—it seems obvious that we ought to reassess our old prejudices against this most abundant of all fossil fuels.

At least Atlantic Richfield thinks so.

There are no easy answers.

ARCO

Atlantic Richfield Company

America's Driving Machines 1982

Dodge 400—The new personal driving machine. Luxury. High performance. High mileage.

Aries K 4-door—America's highest mileage 6-passenger sedan.

Aries K wagon—America's highest mileage 6-passenger wagon.

Omni Miser—The highest highway gasoline mileage ever achieved in an American car.

Mirada—The personal car engineered for excellence.

024 Miser—The highest mileage front-wheel-drive American sports coupe.

Aries K 2-door—America's highest mileage 6-passenger coupe.

Charger 2.2—A lot of go without the guzzle. 0 to 50 in 6.6 seconds, 41 26 mpg.*

The new Dodges.

The 1982 front-wheel-drive Dodges get you off the mark fast. They hug the road when you're taking a turn or cresting a hill. They slip deftly into narrow parking spaces. Sophisticated technology propels them, and graceful aerodynamics ease them through the wind. They have the characteristics of the traditional European driving machines, but they're American, designed to meet today's realities. That means the new Dodges carry full size adults with room to spare. They perform as brilliantly at the pump as on the road. And, most exciting of all, you can afford them.

Driving excellence by design

Tests this year showed that our new Charger 2.2 can go from 0 to 50 mph in 6.6 seconds. That's faster than a standard 1981 Porsche 924. In comparisons of EPA estimated highway mpg, Dodge Omni Miser is rated to drive further on one gallon of gasoline than every Datsun made. Our Aries K has a smaller turning radius than Chevy Citation, so you can maneuver more easily out of a tight spot. All this mastery of the road comes from Dodge technology. Our front-wheel-drive helps you grip the pavement, even when slick. Our MacPherson strut suspension lets you feel the road without suffering the potholes. And rack-and-pinion steering gives pin-point accuracy in hairpin turns.

Superior mpg

American driving machines also excel in driving past the pump. Omni Miser, for example, gets the highest highway gasoline mileage of any American built car. Chrysler Corporation cars have a projected corporate average fuel economy of 28 mpg. Our 1982 cars have achieved fuel efficiency standards 3 years ahead of the EPA deadline for the rest of the auto industry.

High technology manufacture for high quality driving machines

Our '82 Omni's, 024's, Chargers and Aries K's are built in some of the world's most technologically sophisticated plants. We use robots to make body welds, because robots weld more precisely than people. We've installed automatic "robogates" to assemble cars tightly and accurately. This advanced technology is paying off. Our 1982 Trans-4 engines are the best quality Dodge ever made. And in tests of ride, drive, style and convenience, the Nationwide Consumer Testing Institute found that consumers** consistently preferred Dodge over the competition. For example, consumers chose the 1981 Dodge 024 over Datsun 200SX by 39 to 11, and they preferred Dodge Omni to VW Rabbit by 42 to 8.

Above-standard equipment

Our driving machines are fitted out for civilized driving. '82 rear-wheel-drive Mirada has as standard equipment power steering, power brakes and automatic transmission. On Omni E-Type Euro Sedan and Charger 2.2, dual reclining sport bucket seats are standard. But the real hallmark of our '82's is the care we've given to achieving quiet. We've muted the 400 as well as our K cars with extensive sound-proofing, so you get an astonishingly silent ride.

Low operating cost

Once you own an American driving machine you'll find it's a bargain to drive. First, there's that great fuel economy. Second, our Trans-4 engines have their service parts up front and easy to reach. So you can do the work yourself and save on servicing. What's more, you pay less on scheduled maintenance too. After 50,000 miles, for example, our 1981 Aries K come in with substantially lower scheduled maintenance costs than Ford Escort or Chevy Citation.

1981 prices for 1982 cars.

We've held the price line on the Dodges America wants most. 1982 base sticker prices on all Omni's and all base model Aries K Coupes and Sedans are the same as 1981. The chart shows how low prices are on the new American driving machines.

	As shown Prices***	Base sticker Prices***	Est. hwy / EPA est. mpg*	Pass. com.
Dodge 400	$8,253	$8,043	40 EPA	5
Charger 2.2	$7,247	$7,115	41 EPA	5
Omni Miser	$5,499	$5,499	52 EPA	5
024 Miser	$5,799	$5,799	51 EPA	5
Aries K Wagon	$8,161	$7,334	40 EPA	6
Aries K Coupe	$6,921	$5,990	41 EPA	6
Aries K Sedan	$7,076	$6,131	41 EPA	6
Mirada	$9,714	$8,619	21 EPA	5

High resale value

If and when you sell your front-wheel-drive Dodge, you may get a nice surprise—the resale price. According to recent National Automobile Dealers Assoc. Used Car Guides, 1981 Aries K Coupe, for example, retained 85.6% of its original price, and Omni's and 024's built during the last 3 years retained over 85% of their original sticker price. So Dodges are easy on your budget when you buy, when you drive and when you sell.

Get high performance on the road, at the pump and in the pocketbook. Buy or lease a new American driving machine from your Dodge dealer.

America's Driving Machines

*Use EPA est. mpg for comparison. Your mileage may vary depending on speed, weather and trip length. Actual highway mileage will probably be less. Calif. ests. vary. **Randomly recruited from the Los Angeles area. ***Sticker prices exclude taxes and destination charges. WSW $58 extra on Aries K, Omni Miser and 024 Miser. Deluxe wheel covers $52 extra on Aries K Coupe and Sedan.

THIS IS WHAT WE GET FOR NOT FOLLOWING THE CROWD.

A camera with a combination of features you won't find on any other 35mm SLR in its class.

A camera so extraordinary that in just a few short months it has become one of the best-selling in America.

More than a camera. An achievement. The Minolta XG-M.

What kinds of features make a camera this outstanding?

Optical precision for sharp, clear pictures.

Convenience features like automatic exposure to make taking pictures as easy as point, focus, shoot.

Important features like metered manual and exposure override that let you give full rein to your creative instincts.

Electronic features to help prevent mistakes.

Handling features like a built-in, textured grip shaped to fit the curve of your hand.

Even professional features like the optional motor drive that automatically advances the film. One frame at a time. Or at a blistering 3.5 frames per second to capture fast action. Like a touchdown pass rifling into the end zone.

And when you want to unleash your imagination, there are more than 45 Minolta computer-designed interchangeable lenses to help you do it. Along with a full system of accessories.

The Minolta XG-M is only the latest in our over 50-year tradition of creating cameras that are not simply cameras, but outstanding achievements.

See it at your Minolta dealer. To find the XG-M, just follow the crowd.

WAIT 'TIL YOU SEE HOW GOOD YOU CAN BE.

MINOLTA

For more information, write Minolta Corporation
101 Williams Drive, Ramsey, NJ 07446
In Canada: Minolta, Ontario L4W 1A4

Product appearance and/or specifications are subject to change without notice.

Modernizing facilities to improve productivity, quality and service.

That's a Bethlehem commitment. And we're succeeding.

As fast as possible, we're investing in new steelmaking facilities that will make us more competitive—at home and around the world.

For example, we've just completed a $110 million electric furnace steelmaking shop. And a $170 million coke oven battery will start operation early next year. In addition, we recently announced a $750 million modernization program, one of the largest in our history.

That program includes three new, advanced-technology continuous casters (a Bethlehem caster is shown here), and the modernization of several high-production finishing mills. Construction of the facilities is planned for completion over the next five years.

These investments clearly demonstrate our confidence in a profitable future for steel. But new and modernized equipment alone won't insure success. It takes people working safer and working smarter, too. And those are other Bethlehem commitments we're living up to.

Bethlehem

Bethlehem Steel Corp., Bethlehem, PA 18016

The Chairman and Council of the
United States First Day Cover Society
extend you a warm invitation to

Become a member of America's most prestigious organization — for collectors of the first editions of America's stamps.

THE CACHET
Museum-quality, *exclusive* works of art by leading artists, reproduced in vivid color and striking detail.

THE STAMP
Each commemorative stamp is issued by the U.S. Postal Service to honor a great person, event, place or other aspect of America's heritage.

THE POSTMARK AND CANCELLATION
The postmark records the date and location of the stamp's first day of issue; the cancellation further establishes the Cover's authenticity.

THE NARRATIVE
Printed on the back of each Fleetwood First Day Cover, this historical account brings the stamp's subject to life. You can never lose it, and it will add to the enjoyment and educational value of your collection.

Covers shown smaller than actual size of 6½ by 3⅝ inches (165mm by 92mm)

Few people realize the pleasure, the wealth of knowledge and the potential profit that can come from collecting official United States First Day Covers — the first editions of America's stamps.

Now, you have the opportunity to begin your own heirloom collection of these treasured collectors' items — simply by accepting this invitation to become a member of the U.S. First Day Cover Society.

UNIQUE AND DESIRABLE COLLECTIBLES

First Day Covers are sought after by astute collectors just as limited editions of works of art are prized by connoisseurs. And for good reason: of the millions — even billions — of stamps printed each year, only a very small fraction have "first edition" status.

The limited quantities produced, the exclusivity of each First Day Cover's original cachet art, the First Day of Issue cancellation and the beautiful stamps themselves make First Day Covers the most desirable way to collect our country's stamps.

WHAT IS A FIRST DAY COVER?

Before a stamp goes on sale at post offices across the country, it is introduced at just one post office designated by the U.S. Postal Service. The First Day of Issue cancellation and special postmark distinguish First Day Covers from all other covers (envelopes) bearing the same stamp. These limited editions become valued collectors' items, never to be duplicated.

THE SOCIETY PROVIDES THE BEST FIRST DAY COVERS AVAILABLE TODAY

First Day Covers issued by the U.S. First Day Cover Society are supplied by Fleetwood, America's oldest and largest creator of philatelic commemoratives.

Over the years, Fleetwood has produced hundreds of First Day Covers on an infinite variety of subjects. Their quality lithography, painstaking attention to detail, and uncompromising excellence in every respect ensure the greatest current and future value of your collection.

ENJOYABLE, CONVENIENT, INEXPENSIVE

Since the Society will send you each First Day Cover as the stamps are issued, collecting requires almost no effort. The Society also:

- Informs you of significant First Day Covers from other countries and provides you with the opportunity to acquire them.
- Offers a complete selection of past U.S. First Day Covers — at a 10% savings for your first six months of membership.
- Provides you with an official engraved certificate attesting to your election to membership. This handsome document is suitable for framing and may be displayed anywhere in your home or office.
- Gives you a membership card which grants you a personal tour, a free memento, and use of the Society's Clubroom when you visit the National First Day Cover Museum in Cheyenne, Wyoming.

All this for the modest cost of $1.95 for each Cover bearing a 18¢ stamp (slightly more for stamps of higher value). This is indeed an extraordinary value, especially considering that it is not uncommon for First Day Covers to increase tenfold in value within a few years of their issue.

SATISFACTION GUARANTEED

Your satisfaction is unequivocally guaranteed. If you are not happy with your First Day Covers — for any reason — you may return them within ten days of receipt for a full refund or credit.

Take advantage of this unique opportunity to explore the world of First Day Cover collecting. Fill out the Membership Acceptance form *today* and mail it to: U.S. First Day Cover Society, National First Day Cover Museum, 1 Museum Station, Cheyenne, Wyoming 82008-0002.

EXTRA BONUS

Display and protect your Covers in elegant hard-cover "book" form with this handsome Album. It is yours to keep if you remain a Society member for only 6 months. (Otherwise, you will be billed for its retail price of $23.50.)

MEMBERSHIP ACCEPTANCE

U.S. First Day Cover Society
National First Day Cover Museum
1 Museum Station
Cheyenne, Wyoming 82008-0002

I accept this invitation to become a member of the United States First Day Cover Society. I will receive a First Day Cover for every U.S. commemorative. I will be invoiced only $1.95 (for stamps up to 18¢), modestly more for higher values. (Shipping and handling included.) If not satisfied with any shipment, I may return it within 10 days for full refund or credit, and resign my membership. I will pay as follows:

☐ DIRECTLY. Bill me with each shipment.
☐ BY CREDIT CARD. Bill my credit card account *at the time of shipment*, and mark my invoice accordingly.

☐ MasterCard ☐ Visa ☐ Diners Club
☐ American Express ☐ Carte Blanche

Card Number _____ Expires _____

Signature _____
All orders subject to acceptance by the Society.

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Please print clearly.

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State _____ Zip _____

Your first shipment will be made within 6-8 weeks of receipt of application. U.S. First Day Cover Society®, Fleetwood® and associated emblems are registered trademarks. The Society is a division of Unicover Corporation.

WWF/Nancy Nash

The panda stands for WWF and for thousands of other animals and plants facing extinction

THE WORLD WILDLIFE FUND (WWF) is dedicated to the conservation of all endangered forms of life. Sadly, the Giant Panda is one of the many species now in danger of extinction.

In a unique and historic example of international co-operation the People's Republic of China have invited WWF to work with them to save the world's most widely-admired animal.

The Chinese Government has been actively engaged in Panda Conservation for many years. Now a WWF team led by the distinguished ecologist Dr. George Schaller is at work in Sichuan Province together with top Chinese scientists under the leadership of Professor Hu Jinchu to carry out an in-depth study of the Panda and its needs for survival in the wild.

A major problem: the Giant Panda's diet demands huge quantities of bamboo and the evidence suggests that the bamboo in Wolong Natural Reserve may be about to flower and die – a serious threat to the survival of Pandas in that area.

Other factors – the Panda's low reproduction rate, internal parasites, dietary and territorial requirements – are also being studied.

Ultimately, to ensure that the Giant Panda has a future, we have to conserve the complex ecosystem in which it lives. This broad conservation philosophy is reflected in the hundreds of well-planned projects which are now being carried out by WWF in over 50 countries.

The Giant Panda is an endangered animal. It is also the symbol of WWF's worldwide conservation efforts to save life on earth.

But WWF needs money – your money.

Please send contributions to the WWF National Organisation in your country or direct to:

WWF International, 1196 Gland, Switzerland.

WWF WORLD WILDLIFE FUND

WWF acknowledges the donation of this space by National Geographic Magazine.

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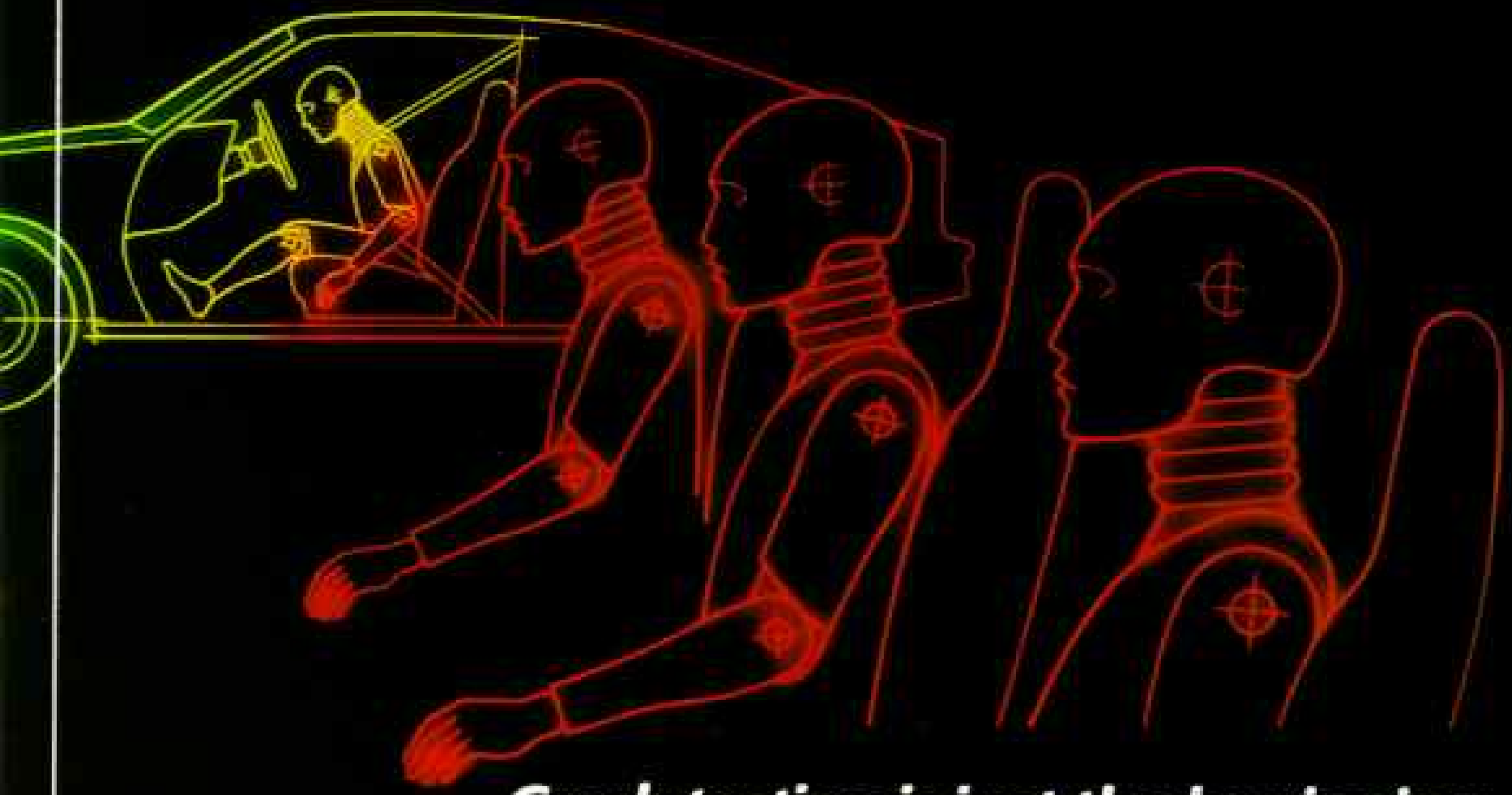

Crash testing is just the beginning.

Crash tests using dummies can help engineers to design safer cars and trucks. That's why we developed much of the technology that has become standard for barrier crash testing throughout the industry.

For example, the Hybrid II anthropomorphic dummy, developed by GM, was the prototype for the government's test dummy.

But we didn't stop there. Our commitment to safety led us into even more advanced research. Today, GM is pushing safety technology forward with new computer-modeling techniques. We've also developed static crusher tests as well as scale-model testing. And our biomedical research is helping us to understand better the human body's response to accident-induced trauma.

All this science and engineering can't take the place of driving carefully and using seat belts. Please do your part; buckle up whenever you drive. For our part, we've accepted a role of leadership in safety. Last year, we spent over half a billion dollars, not including equipment installed on vehicles, to carry out that role.

That's the GM idea of how to use technology to build cars and trucks. Attention to details where you don't see them, as well as where you do. Appearance and comfort may sometimes sell a car, but today's customers demand real value.

Our goal, as the world's largest automotive manufacturer, is to maintain our lead by using new technology to build cars and trucks that perform better and last longer, with lower maintenance costs, than those built by any competitor.

General Motors

The future of transportation is here.

GM

Meeting Japan's Challenge

Third in a Series

HOW THE SIMPLEST BUSINESS PRINCIPLE OF ALL TURNS COMPETITORS INTO CUSTOMERS.

If you make a better quality product than your competition, customers will buy it.

We at Motorola have seen this simple principle make significant differences in the international electronics industry we are part of.

For example, in recent years quality improvements by many Japanese companies have resulted in major inroads for their products into world markets, especially in consumer electronics.

But the same principle of quality has turned some of those Japanese competitors into important customers of American firms such as Motorola.

A case in point concerns communications equipment Motorola designed and built for NASA. Our equipment has been used on every manned and most unmanned space shots without a single mission-endangering failure. Not one. So impressed was the Japanese Space Agency with the quality of our space communications technology and our reliable performance they have specified Motorola equipment for use on many of their space missions.

Closer to earth, a Japanese national named Junko Tabei, the first woman ever to climb Mt. Everest, used an FM portable two-way radio made by Motorola here in America to help guide her to the top. It withstood nights of 20° below zero and days of blinding blizzards. Small surprise that with plenty of Japanese radios to choose from, Ms. Tabei also specified Motorola for her next climb, this time to the roof of Tibet.

And the examples go on. Even though Motorola has bowed out of the consumer electronics market, Japanese companies that are today's giants in that industry buy millions of quality components from our Motorola Semiconductor Products Sector.

All this isn't happenstance. It is the systematic result of Motorola programs, pioneered and developed over the past decade, to give all Motorola employees a greater sense of involvement in, and responsibility for, the quality of the products they design and manufacture.

So, when we receive quality supplier awards from companies such as General Motors, Control Data and even Hitachi, we know why.

And we're proud of that kind of response. It supports our belief that quality is not only the oldest and simplest principle of business. It also is the most important.

MOTOROLA *A World Leader In Electronics*

Quality and productivity through employee participation in management.

Germany, now only $3.15

It's the new low rate. $3.15 for a 3-minute call to Germany. Just dial the call yourself during the lower rate periods, any night 5 p.m. to 5 a.m.

No International Dialing in your area? You still get the same low rate as long as it's a simple Station call. (Person-to-person, credit card and collect calls, for example, cost more because they require special operator assistance.) Just tell the local Operator the country, city, and telephone number you want.

Here's how easy it is to dial Munich:

INTERNATIONAL ACCESS CODE	COUNTRY CODE	CITY CODE	
011	+ 49	+ 89	+ LOCAL NUMBER

(If you are calling from a Touch-Tone* telephone, press the "#" button after dialing the entire number. This will speed your call along.)

$3.15! What a nice surprise! Or . . . as they say in Germany, "Ach Du lieber!"

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Luxembourg	4.05	3.15 B
Monaco	4.05	— A
Netherlands	4.05	3.15 B
Norway	4.05	3.15 B
Portugal	4.05	3.15 B
San Marino	4.05	3.15 B
Spain	4.05	3.15 B
Sweden	4.05	3.15 B
Switzerland	4.05	— A
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Bell System

Ach Du lieber!"

AAOHA

Say hello to gentle trade winds and warm, friendly smiles. Hawaii. Where lush islands, blue ocean and remarkable people come together to create paradise. An American Airlines 747 is ready to introduce you to Hawaii any day you choose. And our special vacation packages let you

discover the islands any way you choose. It's all part of the special service you've come to expect from American. So call your Travel Agent or us and say hello to Hawaii. Once you do, you'll never say goodbye. Just Aloha.

We're American Airlines. Doing what we do best.

SHEAFFER EATON **TARGA**

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Like fine fashion, a Sheaffer has graceful lines, scrupulous detailing and a flawless finish. But unlike fine fashion, when a Sheaffer isn't being worn, it writes beautifully.

On Assignment

IN TWO DECADES of tramping the world's far corners, naturalist ***George B. Schaller*** has picked up enough of such languages as Urdu and Swahili to get by. But communicating with his Chinese colleagues while studying pandas in the wild proved a problem.

"Chinese is a tonal language and, unfortunately, George is tone-deaf," says his wife, Kay, who assists him in the field. "When George pronounces a word, he completely changes the meaning, which gives the Chinese no end of amusement."

Tracking rare and shy pandas in Sichuan Province was no easy job either. "I observed them only seven times in the first six months," he recalled. Despite these difficulties, Dr. Schaller became the first Westerner to photograph these animals roaming free. His firsts also include the only photographs taken in the wild of the elusive Asian snow leopard, published in the November 1971 GEOGRAPHIC.

Born in Berlin, he came to the United States

RAY SCHALLER

at 13 and pursued his interest in animals at the University of Alaska and the University of Wisconsin. He wrote of his study of mountain gorillas in Zaire in *The Year of the Gorilla*, helping dispel the image of King Kong belligerence in the great ape. *The Serengeti Lion*, a subsequent work, chronicles his three-year field study in Tanzania; it won Dr. Schaller a National Book Award in 1973.

THE COUSTEAU SOCIETY

MENTION ***Jacques-Yves Cousteau***, and visions of the sea invade the mind. He was co-inventor in 1943 of the Aqua-Lung, the underwater breathing apparatus that totally revolutionized exploration of the deep. Now man could truly swim with the fishes.

With his research ship *Calypso* as a seaborne base, Cousteau has opened wide the field of underwater archaeology. The National Geographic Society was an early supporter of his work. From one of his first sites, a 2,100-year-old Greek ship, divers recovered a still sealed wine amphora. Cousteau was offered the first glass. With Gallic aplomb, he sipped it, spat it out, and announced, "That was a bad century."

An adventurous French boy, Cousteau at 10 learned to dive in Vermont's Harvey Lake during a year spent in the U. S. Recently learning that the lake was slated for development, he pledged $13,000 to help preserve it.

Currently director of the Monaco Oceanographic Museum and president of the worldwide Cousteau Society, the 71-year-old oceanographer plans a new multimillion-dollar Cousteau Ocean Center for the Norfolk, Virginia, waterfront. It will include a science facility to monitor and evaluate marine ecosystems, educational exhibits on ocean health, technology, and energy sources, and a display of various Cousteau-designed undersea craft.

He hints at even greater marine breakthroughs to come. As he says, "We have only scratched the bottom."

Buick Skylark. It just might be the best-disguised economy car in America.

We find that we must continually re-emphasize the economical aspects of our very popular Skylark.

That may not be romantic, but it seems necessary. After all, Skylark's other attributes are so obvious. It exudes refinement, elegance. And the reality is even nicer than our picture. (Power steering and power brakes, for example, are standard equipment.)

On the other hand, Skylark's economical nature doesn't show through anywhere. That's because we keep it hidden discreetly under the hood. (Just peruse the numbers in the box.)

41 EST. HWY.	26 EPA EST. MPG

Use estimated MPG for comparison. Your mileage may differ depending on speed, distance, weather. Actual highway mileage lower.

Some Buicks are equipped with engines produced by other GM Divisions, subsidiaries, or affiliated companies worldwide. See your Buick dealer for details.

BUICK

Wouldn't you really rather have a Buick?

THE CLARITY OF OUR SHARPEST PICTURE EVER. THE FIDELITY OF 4 SPEAKERS. THE VERSATILITY OF 112 CHANNELS. ZENITH HAS NEVER BEEN CLOSER TO PERFECTION.

There's never been a television set like it. It's Zenith System 3. And it's the best Zenith ever.

You get the sharpest picture in Zenith history on all 19" and 25" (diagonal) System 3 models. 25% sharper than ordinary TV, because of Zenith's patented PRP circuitry. You receive all the picture detail a TV station transmits.

You get up to four acoustically matched and balanced speakers. Woofers up to 8," tweeters up to 2¼." In some models, you even get a 10-watt* amplifier and separate bass and treble controls.

You get a TV that on most models has 112-channel capability, including 42 cable channels.

And you can get the ultimate in remote control convenience—Computer Space Command. It turns the set on or off, adjusts volume, scans or changes channels—up or down. Even prints out the channel and the time.

That's not all. You can preprogram most Zenith System 3 models to turn on and off automatically. And this new Time Control Programmer can be activated (or deactivated) by Computer Space Command.

Many of the System 3 models feature Advanced Space Phone.™ Push the Space Phone button and your Zenith works just like a remote telephone.

Zenith System 3. Zenith has never been closer to perfection.

ZENITH

SYSTEM 3

ZENITH®

THE QUALITY GOES IN BEFORE THE NAME GOES ON.®

Model shown: The Marlborough, Model XX2575E. Oak veneers, solid and simulated wood products in Antique Oak finish. Simulated TV picture.

*With maximum continuous RMS power at 4 ohms, from 100 Hz to 10,000 Hz with 2% or less total harmonic distortion.

our report on Ireland and Northern Ireland, we group longer, interrelated articles to enhance one another." Sometimes coverage may stretch over months or even years, as for the lead story in this issue, which describes Mount St. Helens a year later.

Three months ago, Mr. Garrett introduced Members Forum, a monthly column of readers' opinion and comment. This issue inaugurates On Assignment, a page devoted to the magazine's contributors.

Three photographers whose work appears regularly in the GEOGRAPHIC swept top honors in this year's Pictures of the Year competition. Jim Brandenburg was named Magazine Photographer of the Year for a portfolio including selections from our articles on bamboo, South Dakota's Badlands, and the Canadian Rockies. Cary Wolinsky took second with photographs from articles on the Madawaska Valley, Northern Ireland, and the U. S. Virgin Islands. And Ted Spiegel won third place with his coverage of "Water: Our Most Precious Resource."

Breaking into a new medium, the Society's News Service took to the airwaves this year with a series of radio reports. Crisp, 90-second interviews by Bob Radcliffe with well-known scientists and with staff writers—such as Mike Edwards, who slipped into Kabul after the Soviet invasion of Afghanistan, or Alice J. Hall, who retraced the life and legend of Buffalo Bill—are distributed by Associated Press Radio to its 850 member stations. Longer features of about four minutes are also prepared with experts like Dr. Eugenie Clark, who probes the mysterious world of sharks, and staff archaeologist Dr. George E. Stuart, who explores forgotten caves of the Maya.

Our Special Publications and School Services division produced 15 new books, 10 of them for children. All together, Society members received nearly four and a half million of these publications. I was especially intrigued by *Splendors of the Past*, which transports readers into a dozen lands to explore lost cities of the ancient world.

The aim of the Society has always been to disseminate greater knowledge of the world and its peoples, and the special task of WORLD magazine has been to satisfy the boundless curiosity of children. Almost from the start, WORLD has had the largest circulation of any children's magazine; now in its seventh year, it reaches more than 1.7 million young readers monthly.

In its July issue this year, WORLD announced the formation of a new club, It's Your World, to promote conservation. The club's first project is a campaign to help save California redwoods by "adopting" a grove with contributions to the Save-the-Redwoods League. WORLD editor Ralph Gray says more projects will follow.

Publication of the double-volume *Book of Mammals* was also gratifying to me, since I have long wanted to offer young members of Society families more compelling educational material. Children old enough to read WORLD will be captivated by these bright volumes, designed to give home and school libraries an authoritative picture encyclopedia of the mammal world.

Films Range From Wheat to Dinosaurs

Countless school-age children have already been introduced to National Geographic educational materials through more than two million filmstrips so far distributed. Or perhaps they have learned about life in a pond, solar energy, or Ice Age hunters from multimedia kits prepared by our Educational Media staff, or watched a film about dinosaurs or the life of a wheat farmer. The National Geographic Society, today more than ever, is reaching into the classroom with lively narration and vivid photography. And now research into microcomputers and videodiscs promises to keep our products on the leading edge of technology.

After decades of members' requests, the Society's Book Service this fall published a collection of photographs, essays, and anecdotes on the art of NATIONAL GEOGRAPHIC photography. Taking us behind the scenes with James L. Stanfield at Windsor Castle or Dean Conger in a Soviet village, *Images of the World* combines classic photographs with comments by the men and women who created them. Also, a separate field guide provides tips and advice for professional and amateur alike.

Next spring our Book Service will venture into the *Lost Empires, Living Tribes* of Mexican, Caribbean, and South American Indians. In the fall readers will take a *Journey Into China* through the work of some 30

***For ushering in** a new space age with the first flight of the shuttle Columbia, astronauts John W. Young (left) and Robert L. Crippen were awarded the National Geographic Society's highest honor, the Hubbard Medal, presented by Society President Gilbert M. Grosvenor on September 10.*

CHANG/MICHAEL LANTON (ABOVE); ROBERT S. ISAACS

writers, photographers, researchers, and translators who crisscrossed that nation of a billion people for two years, covering even those areas normally inaccessible to foreigners, with the help of Xinhua News Agency and China's Institute of Geography.

From China's deserts to Peru's mountains, National Geographic teams continue to visit the world's most interesting corners, bringing earth's peoples a little closer, perhaps, by helping them share their perspectives with one another. The Society's role has grown even larger in the world of science, where its grants of 2.5 million dollars this year help continue the essential discourse of research.

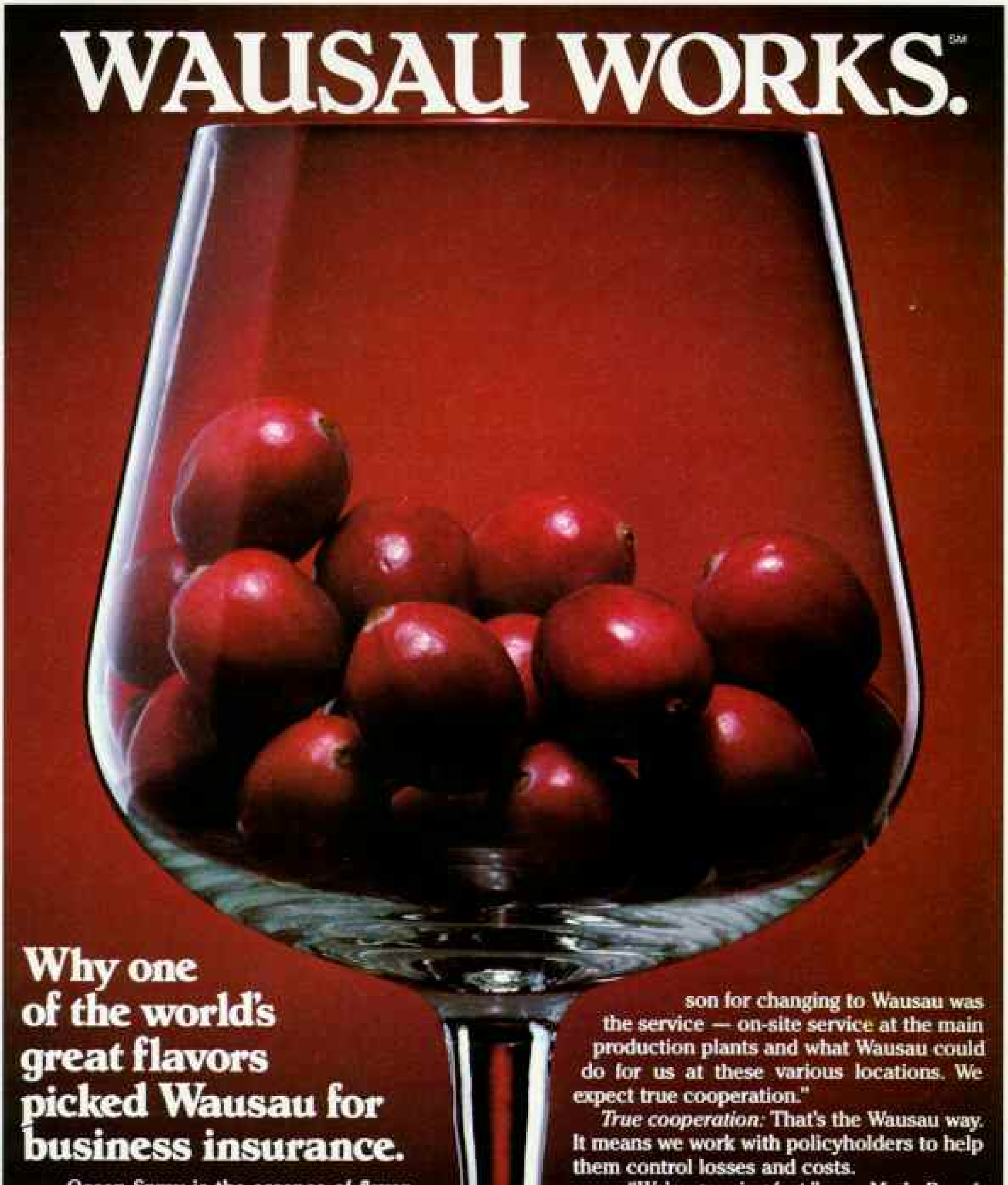
"This financial support makes quite an impact on the basic sciences," said Dr. Melvin M. Payne, Chairman of the Society's Board of Trustees and Committee for Research and Exploration. "A large part of the research sponsored by the Society might not otherwise be done."

The largest grant this year helps pay for a new survey of the northern heavens with the Schmidt telescope at Palomar Observatory in California, probing twice as far into space as the first survey in the 1950s, which was also supported by the Society. When combined with similar photographic mapping under way in Australia and Chile, the Palomar survey will provide astronomers with the first complete sky atlas.

In Turkey, archaeologists funded by the Society continue to piece together the ancient Greco-Roman city of Aphrodisias, subject of an article in our October issue. Across Africa, wildlife experts supported by the Society fight to conserve the remaining herds of African elephants by studying their behavior and ecology. And in remote regions of the Himalayas, a young scientist aided by a Society grant is trying to radio-track the elusive snow leopard, about which so little is yet known.

These far-flung projects are the direct result of your membership in the Society and your encouragement of others to join. Each month thousands of you recommend friends by using the membership form in the front of the magazine. With the same vigor and dedication that have made the Society a unique institution for nine decades, the staff of the Geographic—and the scientists it helps support—will continue to push at the frontiers of man's knowledge of earth, sea, and sky. As a partner in these endeavors, you have good reason to feel proud. □

WAUSAU WORKS.℠



Why one of the world's great flavors picked Wausau for business insurance.

Ocean Spray is the essence of flavor — in cranberries, grapefruit juice, and many blended juice drinks. For essential protection, they came to Wausau.

Robert LeBoeuf, Assistant Treasurer and Insurance Manager for the Ocean Spray cooperative, says, "The reason for changing to Wausau was the service — on-site service at the main production plants and what Wausau could do for us at these various locations. We expect true cooperation."

True cooperation: That's the Wausau way. It means we work with policyholders to help them control losses and costs.

"We're growing fast," says Mr. LeBoeuf, "and it's important to us that Wausau helps protect the number one brand in cranberries and its 800 growers."

The partnership is working for Ocean Spray. And Wausau's blend of insurance services can work for *your* company.

WAUSAU INSURANCE COMPANIES
Wausau, Wisconsin 54401

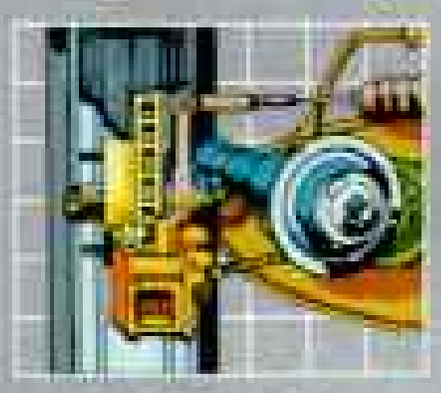
FORD FAIRMONT FUTURA

More car. Less money.

The four-door Fairmont Futura for 1982 is the only car in America with more standard features and a lower sticker price than last year.* That is the simple, surprising fact of the matter. More car. Less money.

How we improved on a solid value.

The new Fairmont Futura four-door offers all the good things it did last year, such as



rack and pinion steering, power front disc brakes and steel-belted radials. But this year you get new dual front speakers on the standard AM radio (may be deleted for credit) and a spacious 16.7 cu. ft. deep-well trunk that gives you lots of room for samples, luggage or bags of groceries in an upright position.

* $6419. Comparison of Aug. 1, 1981, sticker price of a 1981 to a 1982 base model Fairmont Futura four-door.

And Ford's sensible 2.3 liter overhead cam engine delivers impressive fuel economy.

33 EST HWY **22** EST EPA MPG

For comparison. Your mileage may differ depending on speed, distance and weather. Actual highway mileage lower.

Lots of room for people and things.

Choose a Fairmont Futura with standard bucket seats and you get room for five. Choose the optional full-width bench seat or the flight bench seat in the Interior Luxury Group option and you'll have room to seat six adults.

Fairmont Futura: the economical answer.

If you're looking at the prices of new cars today and wondering whether there is one priced for you, the economical Fairmont Futura could be your answer. Whether you buy or lease, see Fairmont Futura now.

More car. Less money. $6419

Fairmont Futura four-door. Manufacturer's suggested retail price. Title, taxes and destination charges extra. Some cars shown with optional equipment at extra cost.

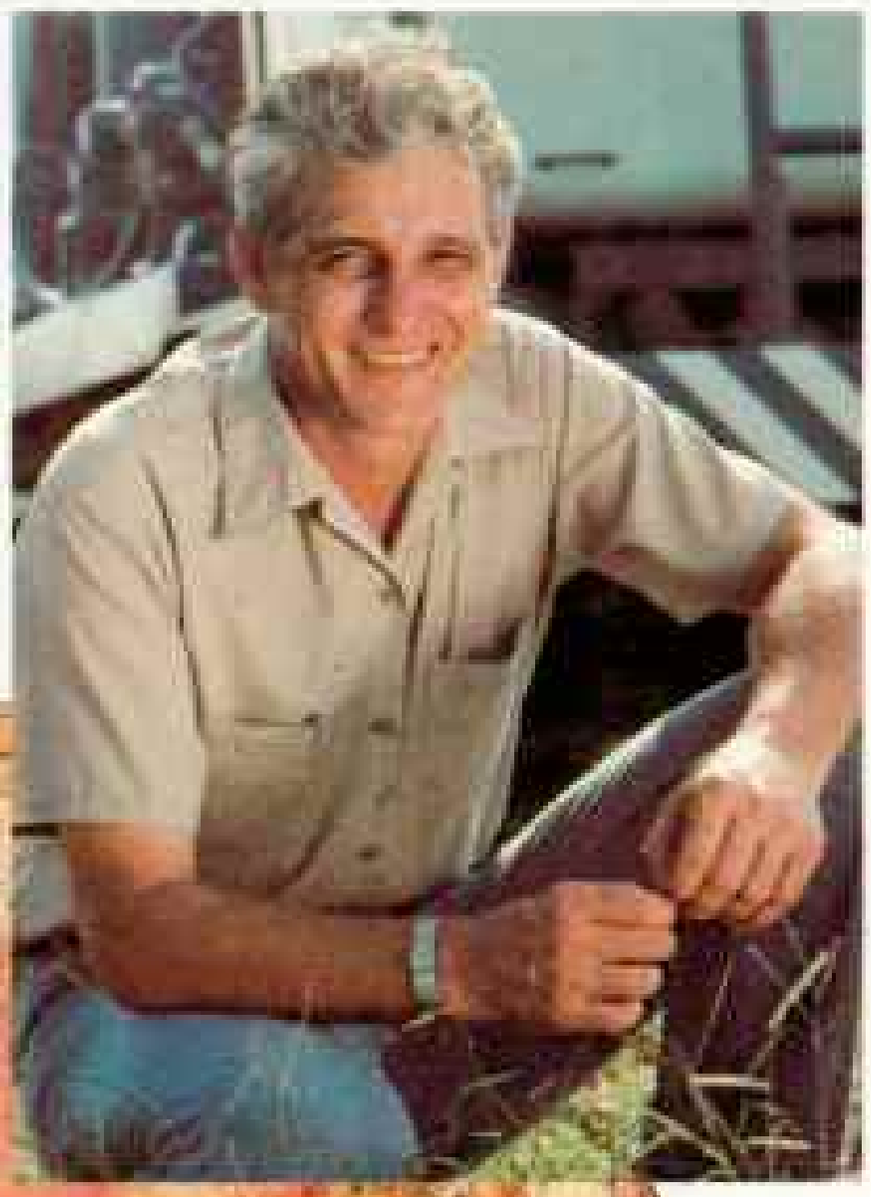
FORD FAIRMONT FUTURA

FORD DIVISION

LOOK OUT WORLD HERE COMES FORD

WE'RE EXXON

We're Jay Stone, making waves in the search for oil.



Finding new oil is one of America's most difficult energy problems. Jay Stone has eased that problem by helping design high-tech trucks that carry unique seismic devices for vibrating the earth.

Unlike similar devices, these Broad Band Vibrators can send much more powerful seismic waves into the ground. And give us a more accurate picture of the rock structures that lie beneath the earth's surface.

By studying charts of the returning echoes, Exxon's explorers can find the areas most likely to harbor oil, and determine the best sites for drilling wells.

Jay Stone's work on Exxon's seismic trucks is helping America reduce its chance of coming up dry in the search for oil and gas. And Stone is just one of thousands of Exxon people who are extending America's reach for American energy.

We're more than 100,000 people working on energy. EXXON

No one colors Christmas

like Kodak. In an instant.

Of all the seasons in the year, there's none with the wondrous color of Christmas. And of all the gifts in the world, there's none that lets you capture these colorful moments and share them like a Kodak Colorburst instant camera.

There's no present like a Kodak instant.

You can choose a Kodak Colorburst instant camera with a built-in electronic flash, for catching instant pictures in any light. You can

Actual size

choose one with a built-in closeup lens, for catching magic instants on little faces. And, of course, they all use Kodak instant color film to let you catch instant pictures that are sharp, rich, and vivid.

Kodak Colorburst instant cameras.

This Christmas, give a Kodak Colorburst instant camera. It's the gift that gives, the gift that shares. And isn't that what Christmas is all about?

The gift of instant joy.

Statement of ownership, management, and monthly circulation of the

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SPORTIN' LIFE

If you want to lead the sportin' life, you need a car that looks the part — without costing your life savings. That's where the Toyota Corolla Sports Hardtop comes in. No other car looks this clean, this classy, this "right" — for a Corolla price.

So get in, sport. You'll find a peppy 1.8 liter 4-cylinder engine. A 5-speed overdrive transmission. Or Toyota's optional 4-speed automatic overdrive. And all kinds of standard equipment you'd expect to pay extra for on most other cars.

Full instrumentation, including an electric tachometer (very sportin'!). AM/FM/MPX stereo radio. Tinted glass. Steel belted radials.

And one more thing. Toyota's total economy. Here's a car that won't complicate your sportin' life with sports car headaches.

Because it's built to be dependable — one reason Corolla is the world's best selling car.

The Corolla Sports Hardtop. One could fit right into your sportin' life.

Photographed by Rod Brindamour. ***Orangutan:*** *Genus: Pongo Species: pygmaeus*
Adult weight: Male—approximately 70kg. female—approximately 37kg ***Adult height:*** *112—137cm*
Habitat: *Tropical rain forests in parts of Borneo and Sumatra in Indonesia and Malaysia.*
Surviving number: *Possibly as few as 2,000 remaining in the wild.*

Wildlife as Canon sees it: A photographic heritage for all generations.

When a work of creation is gone, there is no way to bring it back.

The orangutan, a primate of unusual intelligence, whose name is in fact a Malay word that means "person of the forest," is in danger of vanishing forever from the face of the earth.

And while photography can record this unique animal for posterity, it can also actually help save it and the rest of wildlife.

As a scientific research tool, photography can show exactly how the orangutan lives in its natural habitat, giving wildlife conservationists the information they need for saving it.

And by bringing the orangutan within our reach, photography can open our eyes to how amazing a work of creation this colorful animal is. A photograph of a female orangutan and its offspring, for instance, is an eloquent picture of motherhood, helping us to better understand the complex and at times mysterious ways of nature.

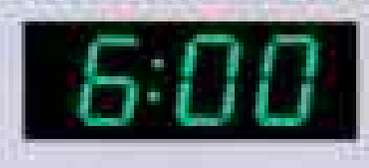
And understanding is perhaps the single most important factor in saving the orangutan and all of wildlife.

Canon
Images for all time

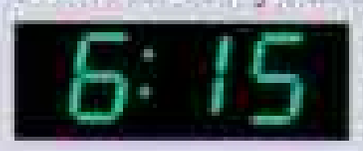
Model 7-4881

THE GE COMPUTER RADIO. AT 6 A.M. IT'S SMARTER THAN YOU ARE.

TIME. For starters, The Great Awakening from General Electric is smart enough to let you set the time directly... there's no flipping around the clock.



WAKE-UP 1. You can program it to change stations for you. So it will rock you to sleep with Strauss, switch to your news station, and wake you at 6:15.

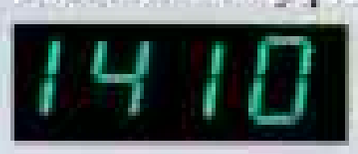


WAKE-UP 2. Then it comes back on to wake up your better half to a Beethoven symphony at 7:53. And on the Great Awakening it's all done with push-button ease.

SNOOZ-ALARM.® For a little extra sleep, press the Snooz-Alarm. It lets you sleep an extra minute or an extra hour. You tell the memory how long.

RADIO FM. You can also program up to six of your favorite stations into the Computer Radio's memory. And recall any one of them with the touch of a finger.

RADIO AM. You can scan all the AM or FM stations by pressing a button or, to tune in one station, just punch in the frequency of your choice on the keyboard.



ERROR. The Great Awakening Computer Radio is so smart it even tells you when you've made an error. But it's no problem to correct.... just press a button.

ALARM OFF. When you forget to set the alarm...The Great Awakening remembers to remind you.

WE BRING GOOD THINGS TO LIFE.

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