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Havoc on Land, Sea

El Nino: the World Turns Topsy-Turvy

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CALLAO, Peru—When it began, the sea change was not recognized for what it was.

Northwest of this port town, the isolated reach of the eastern Pacific Ocean along the Equator remained misleadingly benign. The few who sailed near at the time remember an eerie, beautiful stillness—a flat sea of glassy waters and little wind. The sun blazed from a crystal-blue sky, interrupted only occasionally by a towering cumulus cloud.

But the temperature of the sea surface during May, 1982, had risen slightly, less than one degree Fahrenheit.

Reports of the subtle warming, measured by weather satellites and drifting buoys deployed by the United States' National Oceanographic and Atmospheric Administration (NOAA), flowed that month into the suburban Camp Springs, Md., office of Gene Rasmusson, chief of the diagnostics branch of NOAA's Climate Analysis Center. Rasmusson thought the readings odd, particularly because the Southern Hemisphere was entering its winter season, but he figured the satellite data probably was faulty.

Pressure Rises Sharply

Then in June, the chronically low atmospheric pressure at a measuring station in Darwin, Australia, on the western side of the Pacific, suddenly rose sharply, while the chronically high pressure at another station in Tahiti, in the central Pacific, fell dramatically.

Rasmusson made a passing reference to the abnormal figures that month at a gathering of American meteorologists and oceanographers in Seattle. A few eyebrows were raised. Then the scientists went on to other business.

"In retrospect, we should have been able to figure what was happening," Oregon State University oceanographer William Quinn said a year later. "The signs were there."

What was happening was the beginning of a natural catastrophe unequalled in this century, associated with a warm ocean current called *El Nino*. In the past year, disrupted weather patterns have wreaked

First of two parts.

havoc across three-fourths of the globe, causing more than 800 deaths and \$8 billion in damage.

For months, the vast natural world has appeared to veer from the laws of rational order. Perennial winds and currents have died or reversed direction. Normal sea levels and temperatures have soared or plummeted. Millions of fish and seabirds have disappeared. Weather systems have been displaced by thousands of miles, withering normally lush lands and turning deserts into lakes.

California, the Rocky Mountain states, the Gulf Coast, Peru, Ecuador and Bolivia staggered under torrential rains, flooding, mudslides and destructive tides, while Australia, Indonesia and southern Africa gasped through record droughts. Some areas accustomed to six inches of rain got 12 feet.

"This warm episode will go down in the records as one of the strongest and in some respects one of the more unusual events of the past century," Rasmusson concluded last fall. "Things unheard of were happening. From a human and economic standpoint, it may also have been one of the most costly. The major socio-economic problems which have been created in many areas of the world can only be completely evaluated after the event has passed into history."

The events of the past year have also encouraged modesty rather than arrogance in those usually accustomed to understanding and mastering the natural world. Armed with the finest instruments modern technology could provide, some of the premier scientists in meteorology and oceanography failed to predict what was to happen, did not believe it when it began, thought it was ending when it was reaching a new peak, and announced it was over when it was still lingering.

In the end, some of them joined the laymen staring heavenward, pondering man's vulnerability to the unfathomable dynamics of the natural world. Their learned conversations became dotted with words such as "awesome" and "humbling." In interviews, some conceded that they simply did not understand what was happening.

'It's Humbling'

"When you see what can happen, how a quirk in the wind can do all this, it's humbling," said Alan Strong of NOAA's National Environmental Satellite, Data and Information Service. "It reminds us what another nature can do . . . It is fascinating that what happens in one area can affect the whole world. As to why this happens, that's the question of the century. Scientists are trying to make order out of chaos."

Finally, in the face of the frightening destruction, the scientists still admired and appreciated what was unfolding. The wondrous, vast dynamics before them conjured thoughts of beauty and elegance side by side with their sense of confusion.

If only they had more data, several top scientists told *The Times*, or grasped more securely the physical laws of the world, they could understand. When questioned, they insisted they still believed there was a rational order where others saw only random chaos or an angry God. Scientists who give in to theological tendencies, they noted wryly, tend to have limited credibility.

Climate Changes Not Random

"Those of us in climatology do not believe that changes in the climate are completely random, that God is playing dice with us," said Jerome Namias, the renowned oceanographer at the Scripps Institution of Oceanography in La Jolla. "It is not a gull flapping its wings somewhere or a grasshopper jumping in the Sahara that twists the whole atmosphere around. . . ."

Peruvian fishermen knew long before scientists arrived with sophisticated instruments that the waters off Peru and Ecuador warmed almost every year, usually around Christmas. For this reason, legend has it, they named the warm current *El Nino*, in reference to the Christ child. Another version says the fishermen originally called it *el corriente del nino*, the little warm current, because it confronted the more powerful cold Humboldt Current that usually flows north up the South American coast.

In recent times, scientists and journalists have come to use the term *El Nino* broadly to describe the more unusual and powerful major warming events in the equatorial Pacific. These warmings have been felt globally seven times in the past 100 years, in 1891, 1925, 1931, 1941-42, 1957-58, 1972 and—the largest of them all—1982-83.

Major Sea Changes

El Nino in this broader sense is literally a sea change.

Normally, the eastern equatorial Pacific is a region of high atmospheric pressure, while the western equatorial Pacific is one of low pressure. Just as water runs only downhill, winds blow only from high pressure to low, so trade winds usually flow from the South American coast westward toward Australia and Indonesia.

These trade winds drag the eastern Pacific's warm surface water to the west with them. This allows cold, nutrient-rich water to well up off the coasts of Peru and Ecuador, making that area one of the most abundant fisheries in the world. It also leaves a thick mass of warm water in the western Pacific. Along the coast of Australia sea levels often are six feet higher than along the coast of South America.

But during *El Nino*, this condition inexplicably seesaws. The normal low pressure zone in the western Pacific switches places with the usual high pressure in the eastern Pacific. Scientists call this event the southern oscillation, but they cannot explain why it happens. They do not know what it causes.

Trade Winds Reverse

The normal trade winds to the west die, and sometimes actually reverse direction, flowing east toward South America.

Without the winds pushing toward the west, the huge mass of warm water sloshes back toward South America in a mammoth surge called a Kelvin Wave. The front of this surge crosses 6,000 miles of the vast Pacific at the rate of five knots, or 125 miles a day.

When the warm water reaches the South American coast, it hooks south along the coasts of Ecuador and Peru and, because warm water is less dense than cold water, overrides the cold Humboldt Current. This blocks the upwelling of cold, nutrient-rich water from the ocean bottom. With nothing to feed on, many species of fish disappear, along with fish-eating seabirds.

Birds, Fish Disappear

(The Peruvian anchovy industry, which had accounted for 38% of the world's supply, was devastated by *El Nino* in 1972, cutting the catch from 10.3 to 1.8 million metric tons.)

The weather also is affected. The warm *El Nino* water along the South American coast through evaporation sends enormous amounts of heat and moisture into the atmosphere. The warm moist air condenses, and heavy rains fall. Meanwhile, Australia and Indonesia, which usually get the warm waters and rains, stay cool and dry. The two sides of the Pacific literally swap systems.

These regions feel the most intense results of *El Nino*, but its effects spread much farther. The warm equatorial sea also forces unusual heat energy into the northern Pacific's atmosphere, which increases the contrast in air pressure between the Equator and the Arctic.

Winds, Tides Hit California

This increase affects both the subtropical and polar jet streams in North America. The eastbound tropical jet, which usually dies out by the time it reaches Baja California, continues to roar eastward instead, bringing abnormal rain and storms to California, the Southwest, the Gulf Coast, Florida and Cuba. The polar jet stream is displaced hundreds of miles to the south, bringing additional torrential rains, winds and high tides to California coastal regions.

"When you add one effect to another, it can add up to more than two," said Rasmusson. "Effects multiply. A small perturbation can make much more of an effect than it seems. . . . When one part of the atmosphere moves, another part feels the kick."

Historical accounts suggest that *El Ninos* have affected man for many hundreds of years.

Eighteenth-Century British pirate ship log books recorded the blood-red patches of plankton that are linked to *El Nino*. Other accounts cite unusual sharks, alligators and yellow-bellied sea snakes in Peruvian warm waters. Tristan Jones, a veteran sailor and author of "The Incredible Voyage," concluded, after researching the topic everywhere from the Maritime Museum in Barcelona, Spain, to the British Museum and Lima University, that one *El Nino* had even helped shape the history of the modern world.

'Changes Aided Conqueror'

Jones believes that Francisco Pizarro, the conqueror of the Incas, prevailed only because he inadvertently happened to find himself sailing down the coast of South America from Panama during an *El Nino* condition. Instead of bucking a powerful northbound Humboldt Current, he was pushed by the warm southbound *El Nino*.

"Had this not been the case," Jones argued, "it would have taken the Spaniards much, much longer to reach the Inca Empire. Atahualpa, the emperor, would have been forewarned by their slow approach and would have been ready for them. The Spaniards would probably have been massacred and the history of the world would have taken a completely different course. More than likely, the Spanish would not

have gained access to the treasures of the Andes, with which to finance their conquests, and the nations of Northern Europe would probably not have been spurred into colonial conquest in order to counter the growing threat of Spanish domination of Europe."

Whatever future seers may make of its political import, this past year's *El Nino* physically has been the largest and most intense in recorded history. Scientists had never before seen so much warm water, at such high temperatures. Surface readings at the Equator reached an astounding 90 degrees Fahrenheit.

Scientists Baffled

But this *El Nino* also baffled the scientists for other reasons. It began at the wrong time of year. *El Nino* usually starts about December, during the Southern Hemisphere's summer. This one began in June, during winter. *El Nino* is supposed to be preceded by a year of heavy buildup of waters and winds in the western Pacific. This one began without any buildup.

The first signs could be seen in the far western Pacific. In Australia, air pressure rose at Darwin in June, 1982. The westbound tradewinds died and reversed direction. The drought began that month in Australia, Indonesia and New Guinea. Sea levels rose at Nauru and a deep blanket of clouds settled over the equatorial central Pacific as the great warm ocean surge began its inexorable eastward movement.

The evidence first became overwhelming in the central Pacific. By July, sea levels at Fanning and Christmas Islands were up 6 to 10 inches. The rains began. The amount of precipitation in July at Tarawa was four times the norm.

By August, the normal low-pressure station at Darwin was recording its highest pressures in a century, and Tahiti was reporting its lowest pressures in 50 years. The current that normally flows westward along the Equator was moving strongly to the east. Five cyclones formed in the eastern Pacific. It started to rain at Christmas Island, during what is usually the beginning of the dry season. Deluges

were reported from the Gilbert Islands (now the independent nation of Kiribati) to the Line Islands.

In September, Rasmusson issued the first of what would become a series of special climate diagnostics bulletins.

A genial, bemused, sometimes self-deprecating man of 54, he was trained in meteorology by the Air Force and later earned a doctorate from the Massachusetts Institute of Technology. He had been studying *El Nino* since the late 1970s, and helped to found NOAA's diagnostics branch in 1979.

In this first bulletin, he stopped short of announcing an *El Nino*, saying that the situation "is as yet unclear."

The scientists simply could not believe their own information. The figures were too bizarre. In fact, the data flowing into NOAA's Climate Analysis Center from satellites, buoys, and merchant ships was actually being rejected. The NOAA computer system was programmed to regard numbers too far from the norm as being the result of faulty instruments.

But at the same time, here in the equatorial Pacific, a small expedition on board *The Conrad*, a research vessel financed by the National Science Foundation, had fewer doubts. Unintentionally, expedition members found themselves in the middle of the fiercest *El Nino* of the century, just as it was springing to full life.

Strange Things Happened

The *Conrad* left Honolulu on Sept. 10 and steamed eastward along or near the Equator to Panama, reaching the canal Oct. 13. The ship's scientists were conducting a large-scale study of current, surface and subsurface temperatures. They were not in the region because of *El Nino*; they had not known it existed.

But the chief scientist on the cruise, John Toole, a physical oceanographer from the Woods Hole Oceanographic Institution, began noticing strange things.

Surface temperatures were seven to nine degrees warmer than normal, and even more importantly, the warm water continued deep

below the surface. Normally, the ocean in this region cools 40 to 50 degrees Fahrenheit (15 degrees Celsius) at a depth of 165 feet. Toole could not find water that cool above 726 feet. What is called by oceanographers the "15-degree isotherm" had been pushed an astounding 561 feet deeper than its normal level.

"I'd never been in water that warm," Toole said.

The oddities continued.

Normally, something called the "equatorial counter current" (EUC) runs eastward deep below the surface, under the main westward flow. Toole could not locate the EUC. It had simply disappeared.

"The currents just weren't acting right," said Vicky Thayer, a Duke University marine biology researcher on board. "Everything was out of kilter. We couldn't find the mammals and birds normally seen in hordes in this area. The stormy petrels were gone. We fished for a long time off the stern, and had Fijians on board who really knew how to fish. They caught nothing."

Toole was in a bad mood, worrying that The Conrad might be behind schedule because one of the ship's engines was broken. Then he took a reading of the ship's position.

"I was amazed. We were traveling much faster than I expected. You usually figure to be going against the current when you're heading east," he said. "But we were being pushed one knot. The current was going in the wrong direction."

When he realized that he was watching the birth of *El Nino*, Toole told Thayer, "We're in it." From the ship, Thayer radioed the news to her supervisor, Richard Barber, director of Duke University's Marine Laboratory.

'Edge of Scientific History'

"You're right out there on the edge of scientific history," Barber radioed back.

"It was awesome. We didn't have control. Nature was more powerful than us, going its own way," Thayer said.

But unbeknownst to Toole, NOAA's computers in Washington still would not believe what was happening. The Conrad's data, so far from the norm, was also being rejected.

In October, *El Nino's* warm surge reached the South American coast. Record rains and flooding far beyond historic levels struck Ecuador and northern Peru and continued unabated for eight months. Rasmusson later called it "part of the most catastrophic and prolonged *El Nino* visitation of record."

On Oct. 18, NOAA's own scientific research vessel, The Researcher, left Rodman Naval Base on the Pacific side of the Panama Canal, cruising west as far as the Galapagos Islands, then south to Callao, just north of Lima, reaching here Nov. 16. Chief scientist Stan Hayes found surface temperatures up to 6.5 degrees Fahrenheit warmer than the norm. The normal westward equatorial current was "virtually non-existent . . . Essentially all surface flow . . . was to the east."

Computers Reject Data

But in Washington, The Researcher's initial data also was discarded by the NOAA computers, as The Conrad's had been.

At the same time, a renowned physical oceanographer at the University of Hawaii, then considered in scientific circles to be "Mr. *El Nino*," also was being misled by his own theoretical model of how *El Nino* is supposed to act.

At the seventh annual Climate Diagnostics Workshop, sponsored by NOAA from Oct. 18 to 22 in Boulder, Colo., Klaus Wyrtki, the renowned oceanographer, flatly insisted there could not be an *El Nino* brewing.

It was Wyrtki's theory, much respected and accepted, that *El Nino* is preceded by unusually strong westbound winds and a huge buildup of water on the western side of the Pacific, which then sloshes back to the eastern Pacific when the winds die. There had been no such prior build up this time—so Wyrtki argued, in a written paper, that there could be no *El Nino*.

Scientists Ignored Signs

"Yes, some in Boulder were saying there was no *El Nino* at the same time people in Peru were getting heavy rain and staring at water 11 degrees warmer than normal," said Rasmusson later, chuckling at the contrast. "It was happening. But people just got locked into their theories and models."

In an interview months later, Wyrtki said, "I never did think that an *El Nino* could develop from a state of rest. I would not have thought the wind field could collapse without a buildup . . . If I were a politician, I'd be embarrassed, but as a scientist, I'm not. We are always learning. That's what we do. We can't go in the lab and alter a situation and experiment. Nature is doing the experimenting. We can only observe."

In October, NOAA decided it was losing too much data through computer rejection. "We started realizing we were throwing the baby out with the bath water," Rasmusson said. "We went back and started to look again at the data from the Conrad and the buoys. We decided that this was good data after all."

Computer Reprogrammed

The computer was reprogrammed to accept the abnormal figures. Rasmusson redrew the September map of the region before its release. With the new figures, it became clear to Rasmusson that *El Nino* was under way. In November, he issued his second special climate diagnostics bulletin, for the first time announcing an *El Nino*. The current situation, he reported, "has now reached the dimensions of a major warm episode . . . There seems little doubt that the (current *El Nino* conditions) are of major proportions, rivaling or possibly even exceeding the events of 1972 and 1976."

In the equatorial Pacific, there was no doubt at all. Chaos reigned.

In November, 4.32 inches of rain fell at Guayaquil, Ecuador, compared to a norm of .22 inch.

The Line Islands reeled under powerful eastbound winds. Fanning and Washington Islands suffered extensive erosion and damage to vegetation on their western shores because of heavy clouds of salt spray blowing inland from the surf. A plantation manager on Washington reported that 50-year-old trees had been undermined and had fallen into the sea.

Hurricane Hits Hawaii

A rare, devastating northeasterly hurricane, Iwa, slammed into Hawaii, causing \$230 million in crop and property damage and killing one. Soon after, French Polynesia was devastated by the first of what would turn out to be six major tropical cyclones.

The captain of The *Machias*, a research vessel traveling along the Equator at the time, reported seeing tree trunks, plastic bottles and rubber slippers streaming by in the open sea.

On Christmas Island, Ralph Schreiber, the curator of the ornithology section of Los Angeles County's Museum of Natural History, and his wife Elizabeth, a researcher, found that the entire bird population of 17 million, which usually reproduces on the island, had disappeared, abandoning their nestlings.

The Schreibers saw an island eerily transformed from the hospitable spot they had visited often before. Harsh eastbound winds, heavy rain, solid cloud cover and high sea levels prevailed. Roads in many areas were impassable for the first time in the memory of inhabitants. A pilot salt pond enterprise was completely underwater, dikes and all.

Birds Disappear

But most striking was the absence of birds on an island renowned as a breeding sanctuary. Where they were accustomed to seeing thousands of blue-faced boobies, the Schreibers found only one nestling and three adults. They saw just six great frigates—and 19 carcasses. There were hundreds of dead lesser frigate nestlings. Where there normally was a population of 14 million sooty terns, the Schreibers in November neither saw nor heard a single one. Christmas Island was devastated.

"We believe that the food supply (fish and squid) has disappeared for the majority of the birds," Schreiber reported. "The result is that adults abandoned the island and the nestlings then starved. Ecological theory indicates . . . it is evolutionarily best to abandon a nesting attempt rather than place undue stress on the adult, who can return to breed again when the food situation improves. We do not know where the adults have gone or if they have survived."

On Nov. 22, NOAA's Researcher left Callao and conducted further tests as it steamed north along 85 west longitude, arriving in Panama

Dec. 6. Chief scientist Ants Leetmaa found that *El Nino* had altered the ocean to at least 3,900 feet, creating a remarkably deep mass of warm water. Near the equator, the 15-degree isotherm was down to 759 feet—594 feet deeper than normal.

One day during the cruise, two bands who had left the ship in a small, motorized inflatable Zodiac raft to conduct tests were brushed by a shark, a creature which normally avoids outboard motor noise. The men caught it and a marine biologist aboard cut it open. The shark was starving.

"You could eyeball it out there," said Jack Cutchins, the Researcher's yeoman. "There were no fish or seagulls. It was incredible. And the ship was hot. Normally the ocean cools us."

The effect of *El Nino* began to extend and appear over the North Pacific and parts of North America. Drought conditions developed from the Philippines eastward through the Hawaiian Islands. The tropical jet stream roared across California and the southern tier of the United States. The normal North Pacific low around the Aleutian Islands reached record proportions, shifting more storms, winds and tides to California.

By December, all measurements flowing into Rasmusson's Washington office were at record levels—for atmospheric pressure, sea temperature, precipitation, isotherms. "It just kept building and building. I was in awe," Rasmusson said.

Scientists Fooled Again

But then, just as the existence of *El Nino* had finally been universally recognized, it played another bizarre trick on its observers.

In January and February of this year all the statistical indicators started to decline. Water temperatures dropped nine degrees. Drifting buoys near the equator that had previously been moving eastward, changed direction and headed west, indicating a return of the current to its normal flow toward Australia. Wind measurements indicated a beginning shift back to the normal westbound flow. The pressure readings at Darwin began to assume normal levels.

Rasmusson, in his third special bulletin, announced on Feb. 14 that "it is now clear that the 1982-83 event will go down in the records as one of the strongest, and in many respects one of the more unusual warm episodes of the century." But he also said that observations and statistics now "indicate that this *El Nino* event may have passed its peak."

He was wrong.

In March, sea temperatures inexplicably surged upward again. Along the coasts of Peru and Ecuador, the waters warmed to a staggering 12 to 13 degrees above normal. The drifting buoys that in mid-January had turned back to the west once more reversed direction and headed eastward. All measurements in April and May exceeded the previous December peaks.

El Nino by June had become a media celebrity, carrying on its shirtnails the meteorologists and oceanographers studying its bizarre pattern. Worldwide, newspapers and magazines devoted articles, columns, editorials and multicolored graphs to the topic. In Washington, scientists such as Rasmusson and J.

Murray Mitchell Jr., senior research climatologist for NOAA, were besieged with dozens of calls daily from persons hoping for predictions.

During one hour in mid-June, Rasmusson fielded calls from a TV station in Minnesota, a magazine writer in Toronto, and an aide to the prime minister of Australia. The prime minister was encamped at Washington's Mayflower Hotel and wanted to know the future of his country's drought.

The Researcher, docking at Callao on one leg of its journey, was greeted by Peru's President, Fernando Belaunde Terry. When the ship returned in mid-July, it was met by television cameras on the pier.

Global Proportions Reached

The attention was understandable. By then, the effect of *El Nino* had reached epic, global proportions.

In desert areas of Peru, Ecuador and Bolivia, where the climate is normally so arid that roofs are not built watertight, 12 feet of rain had fallen, compared to a norm of 4 to 5 inches. Meanwhile, in agricultural regions of north Bolivia and south Peru, there had been no rain in eight months. Only 10% of Bolivia's staple, the potato crop, had survived. Roads, including the Pan American Highway, ended in lakes several miles long. Some 40,000 adobe homes had melted. Urban sewer systems had burst. The Galapagos saw more rain in one six-week period than it normally sees in six years.

Some U.S. officials began to fear that the disruption caused by the natural catastrophes was serious enough to threaten the stability of the Andean democracies of Peru, Ecuador and Bolivia. The United States pledged \$48.6 million worth of food as part of a support program.

Drought Losses Mount

On the other side of the Pacific, Australia had endured the driest summer in two centuries. Huge brush fires had ravaged the countryside. Crop, livestock and property damage approached \$3 billion. Nineteen African countries, many in the southern portion of the continent, had endured property and crop damage of \$1.2 billion. The corn and wheat crops were decimated, rivers were dry, lakes too low for irrigation. Cattle, sheep and goats died by the thousands. Zimbabwe, a major beef producer, faced the need to relocate 1 million head of cattle.

Micronesia was running out of drinking water and facing serious public health problems, including an outbreak of infectious hepatitis. A quarter of the food crops and a half of the coconut harvest, a major cash crop, were lost. Between January and June, Ponape and Yap, which usually get 180 and 110 inches of rain respectively, received just 5.5 inches. Water for Yap's capital of Colonia had to be pumped from a swamp, trucked to town and chlorinated.

India, Sri Lanka and Indonesia endured 340 deaths and \$650 million in crop damage, and Mexico and Central America lost \$600 million, all from drought. Cuba suffered 15 deaths and \$170 million in property and sugar crop damage because of heavy rains and flooding.

It was the wettest spring on record for much of the United States from the Deep South to Chicago and

across New England. Many areas of the Northeast got twice their normal rainfall; Los Angeles had nearly triple its norm.

California and other Pacific and Rocky Mountain states suffered \$1.1 billion of damage from beach erosion, landslides, floods, tornadoes, crop and livestock losses. Heavy snowpacks in the Sierra Nevada and Utah Mountains triggered destructive mudslides and flooding in Utah and Nevada and, ultimately, along the Colorado River. A severe blizzard slammed into Denver in late May. The Gulf Coast states suffered 50 deaths and \$1.1 billion of damage, with rain-bloated rivers cresting at record highs in Texas, Arkansas, Mississippi and Louisiana.

The nature of marine life off the coast of California dumbfounded veteran fishermen, who found species that did not belong and who could not find those that did. Millions of tiny red crabs washed ashore in Southern California, clogging pipes at the San Onofre nuclear plant. On Monterey Bay, the sardine, which had disappeared after World War II, reappeared, conjuring dreams of a return to the world of John Steinbeck's Cannery Row. Seahorses and marlin were spotted off Huntington Beach. Jumbo squid and anchovies were spawning.

Changes Unexplained

To the north, on the Farallon Islands near San Francisco, the Christmas Island disaster was replayed. Some 300,000 birds normally congregate there during spring and early summer, making it the largest breeding ground for seabirds in the continental United States. But they feed on shrimp-like krill, anchovies and young rock fish that flourish in upwelling cold water. Without the cold water, the food chain was disrupted and the birds disappeared.

Sitting in Washington in June, a frustrated Rasmusson could not answer many of the questions he was hearing. The pressure readings at Darwin and Tahiti had returned to normal, but The Researcher had traversed the equatorial Pacific twice more that month and found no upwelling of cold water. Temperatures had stayed warm.

"There's a hell of a lot of things we can't explain," he said. "How does this thing end? What shuts it off? The SOI (southern oscillation index) has dropped, but the sea surface temperatures are still historically high. There's no resolution. It's still gigantic. It ought to go away, but it hasn't. I don't know what will happen this year."

Rasmusson issued another bulletin in June summarizing the past year's events, but he could not put an end to his story. "The future course of the warm episode," he concluded, "was still in doubt at the time of this writing."

After five months at sea, The Researcher was scheduled to return to home base in Miami by the third week in July. But Don Hansen, director of the physical oceanography division at NOAA's Atlantic Oceanographic and Meteorological Laboratory in Miami, arranged a six-day extension so more tests could be conducted off Peru and Ecuador. He also asked that a NOAA Research Facilities Center airplane, usually used for hurricane watch off Miami, be dispatched to conduct additional airborne tests farther west of the Researcher's

route in the equatorial Pacific.

"Odd things are still happening. We're still seeing it," he explained. "The event may be in its waning weeks, or it could gather new vigor next winter. In either case, it is an event of historic dimensions for which additional observations . . . are required."

The Researcher left Callao July 16, its mission to learn whether *El Nino* was dying or regenerating for another year of life.

Meanwhile, scientists in Washington and throughout the country were faced with an even larger and more unfathomable question: What caused the historic, catastrophic *El Nino* of 1982-83 in the first place? Was it part of an ordered, rational system that could be predicted and understood, or was it a product of random chaos in the natural world?