Coral bleaching in Jamaica

SIR—Since early October 1989, corals in Jamaican reefs have begun to lose their pigmentation (bleach). As in the 1987–88 bleaching event in the Caribbean[1], all varieties of reef-building corals, ranging from the surface to more than 30 m depth, are affected. Repeated dives along the north coast of Jamaica and reports from divers indicate that the phenomenon is widespread, and that it began no earlier than late September.

As in the earlier event, bleached corals are common in all fore-reef waters, are relatively uncommon in the back-reef and are not confined to areas of unusual local environmental stress[2]. No new bleaching occurred in Jamaica in 1988, except for reefs just downcurrent from major river inflows, which were heavily bleached for about a month after large amounts of muddy freshwater runoff were dumped on them by hurricane Gilbert. Areas affected by the hurricane and those untouched by it are now bleaching.

Although the bleaching event still seems to be in its early stages, the overwhelming majority of corals are already affected. Many species have already completely lost their pigmentation, leaving areas of bleached white skeleton or tissue (for example *Agaricia*, *Millepora* and *Palythoa* species), some have preserved secondary screening pigments which make the colony appear unusual blue, green or pink colours (such as *Siderastrea*), whereas others have become very pale (such as most *Montastrea*, *Diploria*, *Porites*, *Eusmilia*, *Dendrogyra*, *Meandrina* and *Erythropodium*). Among the reef-building corals, only *Madracis* and *Acropora* seem minimally affected. Although the intensity of bleaching has not yet reached the greatest levels reached in late 1987, this year's event seems to be more widespread: *Montastrea annularis* colonies that bleached in 1987–88 are bleaching again, accompanied by pigment loss in colonies unaffected by the previous event. Many Jamaican genera (such as *Agaricia*, *Siderastrea*, *Porites* and *Diploria*) are much more strongly affected than by the previous episode.

As yet, there are no reports of bleaching elsewhere in the Caribbean (E. Williams, personal communication). It will be important to document whether the phenomenon is occurring in other parts of the region, as well as its onset and duration. Information should be sent to Dr Ernest Williams, Caribbean Aquatic Animal Health Project, Departamento de Ciencias Marinas, Universidad de Puerto Rico, PO Box 5000, Mayaguez, Puerto Rico, 00709.

The 1987–88 bleaching event began in late July, reached its peak around December and was largely complete by March 1988 (ref. 2). Maximum seawater temperatures in Jamaica are generally reached in October or November, but in 1987 temperatures rose early, and did not begin to fall until December. In October 1989, ocean temperatures along the north coast of Jamaica were above 30 °C, and were at this level since at least early August. If bleaching is linked to a physiological reaction of corals and their symbiotic algae to elevated sea temperatures[3,4], the phenomenon could continue for at least a further month or two, depending on the time course of heat storage in Caribbean waters.

The 1987–88 bleaching episode raised concern of possible linkages between coral bleaching, rising tropical sea surface temperatures and the greenhouse effect, but its failure to appear in 1988–89 allowed the phenomenon to disappear from public awareness. Although it is too early to predict the ultimate severity or duration of the 1989 episode, there should be serious concern about its regional economic effects and global environmental implications.

During the nine months of the 1987–88 bleaching event, Caribbean reef-building corals failed to grow[2]. Repetition of such events will alter the food chain of the coral-reef ecosystem, making corals less able to compete with rapid growth of fleshy algae. They could ultimately convert coral reefs into algal habitats, with severe economic losses from deterioration of reef fisheries, tourism and shore protection. Recent information suggests that the 1989-90 event has peaked and is concentrated in Jamaica. (Details of the distribution and course of the event are in preparation, Caribbean Research Community.)

Because Caribbean coral bleaching may be a visible warning of the early stages of global warming, there is a case for building now the means for monitoring the phenomenon of coral bleaching and the research capability for understanding its causes.

THOMAS J. GOREAU
Discovery Bay Marine Laboratory, University of the West Indies, Jamaica

Received 23 October 1989.

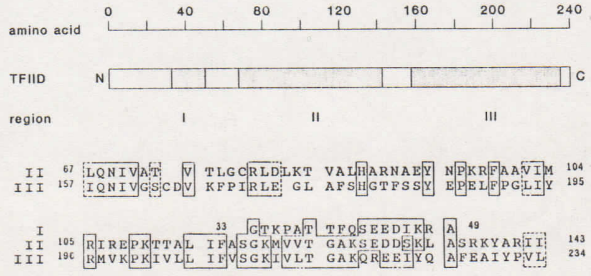
1. Williams, E. H., Goenaga, C. & Vicente, V. *Science* **238**, 877–878 (1987).
2. Goreau, T. J. & Macfarlane, A. H. *Coral Reefs* (in the press).
3. Hayes, R. L. *Coral Reefs* (in the press).
4. Sandeman, I. *Proc. Ass. Island Marine Labs. Carib.* **21**, 50 (1988).

Cryptic initiation sequence revealed

SIR—Several groups[1-3] have recently cloned the gene encoding the protein binding to the TATA box and known as TFIID. This protein plays a key role in the initiation of transcription by polymerase II by binding specifically to the canonical AT-rich element found in the promoter region of many eukaryotic genes. The cascade of reactions triggered by binding of TFIID to the TATA box ensures the accurate start of the transcription process.

The nucleotide sequence of the TFIID gene corresponds to a protein of 240 amino acids with no strong sequence homology to any known polypeptide and in which there are no obvious functional domains or highly conserved motifs. The significance of the weak similarity with parts of the prokaryotic sigma factor, which performs an analogous function in bacteria, is uncertain[1-4].

But careful inspection of the TFIID amino-acid sequence reveals that a major portion of the protein is made up of two segments with clear homology with each other. Direct alignment (see figure) and matrix comparison (data not shown) show that the region from amino acid 67 to 143 (II in the figure) is very similar to the region (III in the figure) from amino acid 157 to 234 (35 per cent identity, 47 per cent strong homology). Moreover, the C-terminal regions of these repeats contains a region (amino acids 121 to 135 and amino acids 212 to 226) having less obvious but still significant homology with the N-terminal stretch of amino acids 33 to 49 (I in the figure). Thus it seems that TFIID consists of a polypeptide repeated twice (or perhaps two and a half times).



Alignment of TFIID regions. Three portions of the predicted amino-acid sequence of TFIID, using the single-letter amino acid code. Identical amino acids are boxed; those with closely similar physico–chemical properties (K,R; D,E; T,S; and V, I and L) are shown in dashed boxes.

This finding has interesting evolutionary, structural and functional implications. TFIID from organisms now extant may have arisen by duplication of a primordial monomer, followed sequence divergence. But the dupl

p. 417

The Daily Gleaner

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Global warming a big threat

THE greenhouse effect and global warming are no longer vague threats that may or may not affect our grandchildren in the future.

Rising sea temperatures are here, and are affecting Jamaica's already over-stressed coral reefs. At immediate risk are: the fishing industry, the tourist industry, and the stability of Jamaica's beaches and coastline. This is the conclusion of marine scientist Dr. Thomas Goreau after studying the recent phenomenon of widespread coral bleaching along Jamaica's North Coast.

Dr. Goreau told the **Gleaner** that the mass bleaching of corals in 1987 and 1989 was the result of raised sea temperatures. He said that all leading coral experts concur with these findings.

Bleaching of coral is a response to stress, for example, temperature fluctuations, light fluctuation, and pollution. Normally, certain species of algae co-exist with corals in mutual inter-dependence, with the coral supplying a habitat for the algae and the algae providing nutrients for the coral.

In adverse conditions, and for reasons unknown, the transparent coral polyps will expel the coloured algae from their tissues and appear to be "bleached". During the duration of bleaching, the coral is starved, or undernourished and ceases to grow. As the sea cools, recovery is possible. The recovery rate varies, but in at least one case, in Panama in 1982, the bleached coral died.

Cooling effect

Localized bleachings caused by localized stress factors have been observed since 1918, but in 1987 and 1989 when Caribbean sea temperatures rose above 30 degrees Centigrade, the first cases of mass bleaching occurred offshore Jamaica, Curacao, Cayman, Florida, Belize and the Bahamas.

There was no significant bleaching during 1988, a fact that Dr. Goreau attributes to the cooling effect of Hurricane Gilbert. However, bleaching occurred offshore Bermuda and in Jamaica there was some bleaching of reefs down-current of large rivers.

Last year, sea temperatures rose above 30 degrees Centigrade in August and by early October 1989 mass bleaching along Jamaica's North Coast was underway. The epidemic now appears to be on the wane, with most corals slowly regaining their pigmentation.

Dr. Goreau told the **Gleaner** that about 80% of the corals were affected and many species showed areas where pigmentation completely disappeared, leaving only white skeleton or tissue. Areas which bleached in 1987 were again affected and bleaching was observed in new areas as well. One of the major reef-builders — **Monastrea annularis** — appears to be especially vulnerable and slow to recover.

One puzzle that remains to be solved is why mass bleaching appears to be confined to the North Coast, with only localized areas affected on the South Coast.

Goreau, whose father, the late Dr. Thomas Goreau founded the Discovery Bay Marine Laboratory, will continue to monitor the situation but his research is limited by lack of funds and the fact that no historical records of Caribbean sea temperatures exist. He is hoping to attract international funding, through the Environmental Defence Fund to organize "a regional response" to the problem and a regional clearing house for information.

"If we don't stop this, what it means is that in the long run the reefs will be dead", Dr. Goreau told the **Gleaner**.

Warming Is Killing Coral Reefs, Scientists Say

Special to The New York Times

WASHINGTON, Oct. 14 — Warming trends are causing the deterioration of the world's coral reefs, a panel of research scientists told a Senate committee last week.

Scientists have been at a loss to definitively explain the widespread bleaching and evaporation of coral reefs, but have said that contributing factors include pollution, sewage runoff and the warming of the earth by the "greenhouse effect," in which pollutants trap heat in the atmosphere. The testimony was the first indication that some scientists investigating the phenomenon had reached a strong conclusion about temperature's role.

"We have found a precise correlation between high temperatures and bleaching," said Dr. Thomas J. Goreau, a senior scientist at the University of the West Indies who is president of the Global Coral Reef Alliance.

Once Bright, Now Ghostly

But one scientist at the hearing voiced skepticism at that conclusion. Dr. M. Grant Gross, director of the Division for Ocean Sciences at the National Science Foundation, said that while higher temperatures in the 1980's might have been enough to cause coral bleaching "we cannot yet prove this hypothesis."

Coral bleaching results from the expulsion of microscopic algae that normally live in the tissues of living coral animals, causing brightly colored corals to turn ghostly pale. Scientists have known that bleaching is usually caused by environmental stresses like extreme temperatures, low salinity and reduced intensity of light, but have resisted drawing a single conclusion.

Since 1988, about 80 percent of the coral reefs in the Florida Keys, Bermuda, Hawaii and the Caribbean have suffered, mostly because the last two years were "the hottest on record," Dr. Goreau said. Scientists are finding that many corals are not coming back and are not as resilient as had been hoped.

"Having suffered repeated bouts of bleaching, coral reefs are beginning to show signs of exhaustion," said Senator Al Gore, a Tennessee Democrat who is chairman of the Senate Committee on Commerce, Science and Transporation, which held the hearing. "Stressed and fatigued, the corals are now dying."

A Warm Decade

The scientists presented data of mass coral reef mortality in the Keys and the Caribbean, as well as charts showing generally higher temperatures in the last decade.

Temperature data presented by officials from the National Oceanic and Atmospheric Administration, the Marshall Space Flight Center in Huntsville, Ala., and by an English climatologi Dr. Philip D. Jones, showed evidence a warming trend in the last decade a supported the conclusions of the co experts.

"Our atmospheric and surface mea urement systems show that the 198 were warmer than the preceding t decades," said Dr. Roy Spencer, space scientist at the Marshall cente

Dr. Jones, of the University of Ea Anglia, said worldwide temperatur in the 1980's were 4 degrees Fahrenh above those of any other decade record and said figures from 19 should continue the trend. The te perature data were based on readin from 33,000 weather stations arou the world. The panel urged Congress set up a coral reef alert center to co pile data on disturbances and analy events of bleaching.

THE WASHINGTON POST

Warm Seas Killing Coral Reefs

Finding May Presage More Ecological Harm

By William Booth
Washington Post Staff Writer

Coral reefs around the world, which biologists say may serve as an early warning system for environmental degradation, are suddenly starving and in many cases dying because of abnormally warm seas, according to leading marine scientists.

The phenomenon, which has occurred three times in the 1980s, may be more serious this year. Coral reefs are blotchy and sickly in many locales, including the Florida Keys, Puerto Rico, Jamaica, the Bahamas, Bermuda, Hawaii and Okinawa, Japan. Researchers say more reports of damage will probably trickle in over the next few months.

Most researchers suspect the current crisis is caused by higher sea temperatures. As the water heats up, the coral polyps that build the reef with their skeletal remains spit out the microscopic algae that help feed the coral and give the reef its golden, red and yellow hues. The phenomenon is called "bleaching" because it leaves the coral with white blotches. Without its algal partner, the coral becomes weak and stops reproducing. After several weeks, it may die.

"Our reefs are in peril and are disappearing at an alarming rate," said Robert Wicklund of the National Oceanic and Atmospheric Administration's Caribbean Marine Research Center.

"We are getting very concerned that this is happening with greater frequency," said Walter Jaap of the Florida Department of Natural Resources. In many cases, we're seeing the corals don't recover." In past episodes, the corals would often return to health. But there is preliminary evidence that repeated stress may make recovery more difficult.

While the marine biologists suspect the corals are being damaged by higher sea temperatures, they are unsure whether the phenomenon is a natural one caused by periodic changes in sea currents, such as the cyclical El Nino ocean upwelling in the Pacific, or whether the planet is warming because of an enhanced greenhouse effect caused by a buildup of pollutants.

At a hearing yesterday on the coral damage before the Senate Committee on Commerce, Science and Transportation, chaired by Sen. Albert Gore Jr. (D-Tenn.), Philip Jones of the University of East Anglia in England reported that 1990 will almost certainly be the hottest year on record. This year has been abnormally warm throughout the Northern Hemisphere, particularly in March, when temperatures in Sibera, Canada and West Africa were as much as 18 degrees Fahrenheit above normal. The 1980s were the warmest decade in the last 100 years.

Researchers in general agree that the Earth on average has warmed by about 1 degree Fahrenheit in the last 100 years. Many climate experts predict that temperatures will increase several degrees in the next century, as greenhouse gases such as carbon dioxide and methane accumulate in the atmosphere, where they act like a blanket to trap heat. However, the exact timing and magnitude of worldwide warming is vigorously debated by scientists.

Many marine biologists believe that the coral bleaching is a sign that the delicate reef ecosystems are suffering from stress. Some suggest that the bleaching episodes are the first biological effect of global warming, and that like canaries in a coal mine, the reefs are a danger signal.

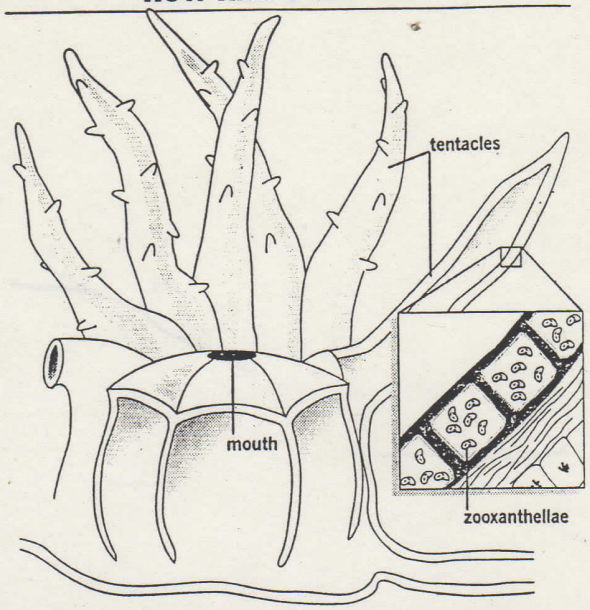
"The first proof of global warming may come from the bleaching of corals," said Ernest Williams of the University of Puerto Rico. But Williams said that not enough is known to conclude that this is the case.

Until the worldwide bleaching episode of 1987, the periodic phenomenon was "virtually ignored," Williams said. He and his colleagues found that there was also widespread bleaching in 1979-80 and 1982-83. There have been isolated reports of bleaching since 1911, though only in recent years have the episodes been so widespread. In addition to higher temperatures, coral reefs may be harmed by pollution, changes in salinity and silt deposits.

Beginning last year, Thomas Goreau of the Discovery Bay Marine Laboratory in Jamaica began to detect bleaching along the entire northern shore. Bleaching is also extensive in the Bahamas and parts of the Florida Keys.

"Like most of my colleagues, I am deeply alarmed at these trends," Goreau said. "If they continue, many coral reefs will cease to be viable in coming years."

HOW REEFS CAN DIE



Reefs are the skeletal remains of tiny creatures known as coral polyps. The coral have mouths, tentacles and contain microscopic, brightly colored algae called "zooxanthellae." These algae use photosynthesis to feed themselves and make food for the coral.

When under stress, the coral loses its colorful algal partners and becomes white, or "bleached." After several weeks without algae, the coral dies.

SOURCE: Scientific American

BY RICHARD FURNO—THE WASHINGTON POST

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The Boston Globe

THURSDAY, OCTOBER 11, 1990

World's coral reefs are being hurt as oceans get warmer

By Dianne Dumanoski
GLOBE STAFF

Stressed by unusually warm water temperatures, coral reefs around the world are suffering damage and some are beginning to die, raising the ominous prospect that the reef-building creatures may be the first victims of global warming.

Marine scientists said yesterday that new evidence indicates that corals are bleaching and dying in a global phenomenon affecting reefs throughout the earth's tropical region. Bleaching is the appearance of stark white patches on the normally green, gold, and brown reefs and occurs when the corals are stressed by something in the environment, such as high water temperatures.

Like the Antarctic ozone hole, coral bleaching is "a totally unanticipated phenonemon" that could indicate serious global environmental change, according to Thomas J. Goreau, a coral biologist from Jamaica who heads the newly founded Global Coral Reef Alliance.

Reef-building corals depend on a symbiotic relationship with algae that live inside their bodies and provide them with vital nutrients. When corals are stressed, they expel the algae and become transparent, making their underlying limestone skeleton visible.

Because the first bleaching reports came from the Caribbean, which has suffered repeated episodes of bleaching over the past decade, it had appeared at first that this was primarily a regional problem.

But reports gathered from roughly 500 scientists around the world by marine researcher Ernest H. Williams of the University of Puerto Rico indicate that the problem, which began in 1979, is also afflicting reefs in Indonesia, Hawaii, Okinawa, Japan, Kenya and the Maldives in the Indian Ocean. Based on these reports, Williams believes that

CORAL, Page 12

World's coral reefs damaged as oceans grow warmer

■ CORAL
Continued from Page 1

this season marks the fourth worldwide bleaching episode in a decade.

The Global Coral Reef Alliance is trying to call attention to the problem, Goreau said, because it could have major environmental and economic consequences. Tropical countries depend on reefs for tourism, important fisheries and protection from hurricane-driven waves. Often called the tropical forests of the ocean, coral reefs are the most diverse of marine ecosystems and home to the bulk of species in the sea.

Sen. Albert Gore of Tennessee, a Democrat who is a leading congressional voice on the climate change issue, has scheduled a hearing today on coral bleaching before the Commerce subcomittee on science, technology and space, which he chairs. Leading climate and coral researchers have been invited, along with officials from the Bush administration.

Marine researchers have found that coral animals live in water temperatures very close to the upper limits they can withstand. Therefore, Williams said, "the coral reef system may be a possible indicator of global warming that we may not be able to see with other means."

Because the bleaching deprives them of nutrients, "the corals are slowly starving" said Goreau, a coral biologist at the Discovery Bay Marine Laboratory in Jamaica.

According to Goreau, water temperatures in the Caribbean appear to be the warmest on record this year, and mass bleaching is taking place on reefs in Puerto Rico, Jamaica, the Cayman Islands and Florida.

"I think it's going to be pretty much all over the Caribbean. It's not only very bad, but this time corals are dying," he said. Coral animals, which build the reefs, have tentacles and resemble their closest relative, the sea anemone.

Recent research has also suggested that massive bleaching and death in coral colonies is a recent and unprecedented development. Because coral animals lay down annual layers much as trees add rings, scientists can investigate the history of a reef by drilling into it and taking out a core sample.

"From studies done so far," said Williams, researchers "are not able to find similar events in the last few hundred years. It seems to be something that just happened recently."

Raymond Hayes from Howard University in Washington added that "the death of a coral colony is not common." He said the coral rings indicated that colonies, which grow upward by only inches a year, have survived for as long as 500 years.

A record of Caribbean Sea surface temperatures over the past decade, which Goreau and Hayes compiled from satellite photos, also indicates that the water there is getting warmer. Since these polar satellite photos go back only a decade, however, it is difficult to see long-term trends.

"It looks for the Caribbean that water temperatures will be the hottest ever" this year, said Goreau.

Measurements by researchers at the Discovery Bay laboratory over four decades have shown water temperatures generally ranging between 78.8 and 84.2 degrees, he said. Last year, when Jamaican reefs suffered bleaching, the sea surface temperature rose to 87.8 in mid-October – more than 3 degrees above normal.

This year, Goreau said, water temperatures climbed even higher, hitting 89.6 in September in Jamaica. It was that hot even "in the middle of the Gulf of Mexico in deep water, which is unprecedented," and hotter still near Haiti and Cuba.

"Unless the bleaching miraculously stops, a lot of these reefs will not make it in the next couple of years," he said. "A lot of them are on the edge, and the prognosis is not good unless the temperature change stops."

Record warmth seen for 1990

Last decade was hottest, Senate told

By Dianne Dumanoski
GLOBE STAFF

WASHINGTON – Alarmed climate researchers told a Senate subcommittee yesterday that the Earth's average temperature is climbing toward an all-time record in 1990.

The scientists, testifying before the Senate Commerce subcommittee on science, technology and space, painted a picture of record warmth during the 1980s followed by unprecedented temperature aberrations in 1990, which will almost certainly be the hottest year recorded in more than a century.

Coral researchers said that heat-stressed coral reefs are sickening and dying in many parts of the tropics and that the future of these biologically rich reefs, often called the tropical rain forests of the ocean, is in jeopardy unless the warming stops.

Sen. Albert Gore, the Tennessee Democrat who chaired the hearing, said what is occurring on the world's coral reefs "may be the first biological signal of global warming."

British climate researcher Philip D. Jones of the University of East Anglia, a member of one of two research teams compiling a record of global temperatures dating to the mid-19th century, said the 1980s "were clearly the warmest decade since the record began." The decade as a whole, he said, was more than one-third of a degree Fahrenheit warmer than any other decade in the record.

Acknowledging that there are uncertainties in using temperature readings taken imprecisely more than a century ago, Jones said the team has done extensive research to determine which records are most reliable and, where possible, it has made adjustments to correct biases in the data. He noted, for example, that the growth of a city around a measuring site could boost temperatures.

Because the first few months of 1990 were exceptionally warm, Jones told the committee, it appears that 1990 will set a record. Land temperatures in January, February and April were almost 2 degrees Fahrenheit warmer than the average for the years 1950-1979, he said.

The month of March, he added, was unlike anything climate researchers had ever seen. Average global temperatures climbed 4 degrees above the 1950-79 baseline period, which Jones characterized as "an amazing anomaly."

In parts of Siberia, March temperatures were 18 degrees above normal, he said, adding, "I was pretty alarmed by these values. But all the numbers were correct. They checked out."

Moreover, he told the panel, "it was anomalously warm all over North America. It was the most anomalously warm month we've ever recorded."

Jones' written testimony noted that because of the record temperatures, there was less snow cover in the Northern Hemisphere during late winter and spring than at any time since satellite monitoring began two decades ago.

Another witness was Roy Spencer, co-author of a research paper that appeared in the journal Science last March and led to news reports suggesting that satellite data for the 1980s, made with precise measuring techniques, contradicted Jones' land- and sea-based temperature measurements. Spencer told the committee that this interpretation was incorrect and that the satellite data from 1979 to 1988 and Jones' record for the same period "correlate quite well."

Spencer, a researcher at NASA's Marshall Space Flight Center in Huntsville, Ala., said reports suggesting the satellite data showed no warming trend in the 1980s had misrepresented the situation, because a decade of data is "quite meaningless" in the context of long-term climate trends.

The conclusion that the 1980s are the warmest decade is based on comparisons of that 10-year span to earlier periods.

He added that if Jones is correct about the warmth in 1989 and 1990, years not yet included in the satellite analysis, he expects to see an upward trend in the satellite record.

Coral researchers told the committee of record water temperatures in parts of the world and showed that the repeated episodes of coral bleaching in the Caribbean over the past decade have occurred when water temperatures have peaked.

Bleaching is the appearance of stark white patches on the normally green-, gold- and brown-hued reefs and occurs when reef-building coral animals are stressed by something in the environment, such as abnormally warm temperatures.

Thomas J. Goreau, a coral researcher from the Discovery Bay Marine Laboratory in Jamaica, said even though there is only a decade of satellite records on sea surface temperatures, analysis has found statistically significant warming trends in waters off Jamaica, Florida, the Bahamas and Bermuda.

Although "regional warming can occur for reasons other than global changes," he said, the widespread bleaching across the Earth's tropical regions suggests the problem is a global one.

"I personally do not doubt the connection between global warming and rising water temperatures," he said, "but I can't prove it."

Warm Trend Reportedly Speeds Death of Coral

VICTORIA, the Seychelles, Dec. 19 (Agence France-Presse) — Coral is dying at enormous rates around the world as a result of rising ocean temperatures possibly caused by global warming, an American expert warned here this week.

The expert, Thomas Goreau, said 80 percent of the coral in the Seychelles and 90 percent of that in Indonesia was already dead, and that the worst is yet to come because sea temperatures are expected to soar to record highs again next year.

Mr. Goreau, president of the Global Coral Reef Alliance, said in an address here that the death of the coral could have serious consequences for the food chain, the economy and the environment.

Few fish feed on coral, but many fish feed on worms, clams and crabs in the coral, and use the reefs for shelter.

"If there are no healthy coral, the fish won't be there," he said, pointing to the potential implications for the fishing and tourism industries.

This year was the hottest ever recorded, according to World Meteorology Services data, Mr. Goreau noted, adding that 1997 had also been a record.

In the Indian Ocean around the Seychelles, he said, the normal sea temperature was 84 degrees Fahrenheit, but at some points it had been recorded as high as 91 degrees.

The higher temperatures are resulting in a "bleaching" of the coral on a scale never seen before, he said.

Such bleaching was first detected in this area in 1987.

"When they are bleached, they are not dead yet, but they are starving and don't reproduce — and this is followed by death if the conditions continue," he said.

He said the only part of the world that escaped the bleaching effect was the central Pacific.

In the second half of 1998, the "hot" water moved north, affecting places like the Maldives and Sri Lanka, and the area between New Guinea and Japan, Mr. Goreau said.

"It has never gotten so hot and for so long," he said. "I think we're right up to the limit of what coral can stand."

In the Seychelles, Mr. Goreau said, coral was surviving best in the muddy and polluted water at the mouth of Victoria harbor, apparently because the cloudiness of the water protected the reefs from the "stress" of sunlight.

Townsville Bulletin 27.11.98
TOWNSVILLE BULLETIN 27.11.98

Coral bleaching killing our reefs

By DEBBIE XINOS

CORAL bleaching is killing the world's coral reef systems.

But according to experts, the Great Barrier Reef has escaped serious damage — for now.

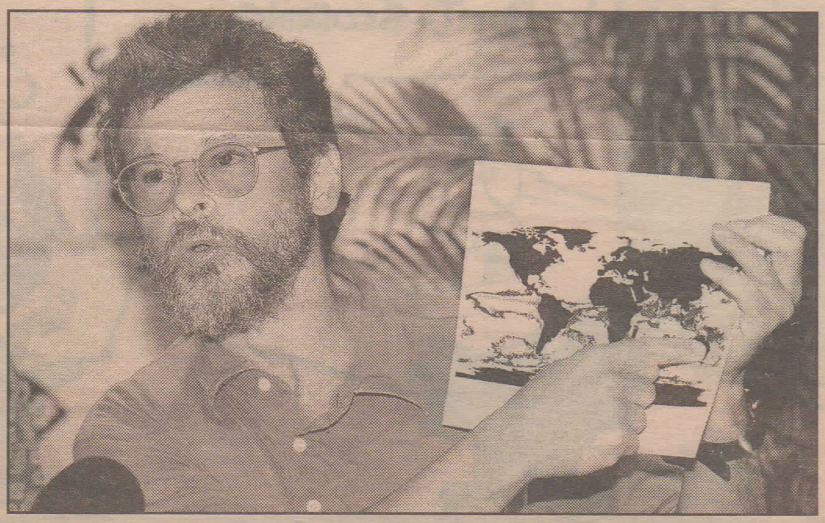
Unless stringent management practices were adopted worldwide the future for even the Great Barrier Reef was bleak, they said.

The warning was issued yesterday at the International Tropical Marine Ecosystems Management Symposium conference in Townsville.

Marine Ecologist Terry Done said this year's warm weather had caused coral bleaching on a record number of reefs.

He said while this could be attributed to unprecedented climatic changes, it was too early to lay blame on the effect of global warming.

"If the projections of global climate change do come about it's likely we will see more years like this in the future," Dr Done said.



AFFECTED . . . Tom Goreau, one of the speakers at the symposium, points to where the coral bleaching has occurred *Photo: LORI NEILSEN*

Add to that increased human activity and the likelihood of widespread coral reef destruction was almost guaranteed, reef expert John McManus said.

Dr McManus said the main concern was the overfishing of reef stocks, which could affect the natural balance between fish and algae.

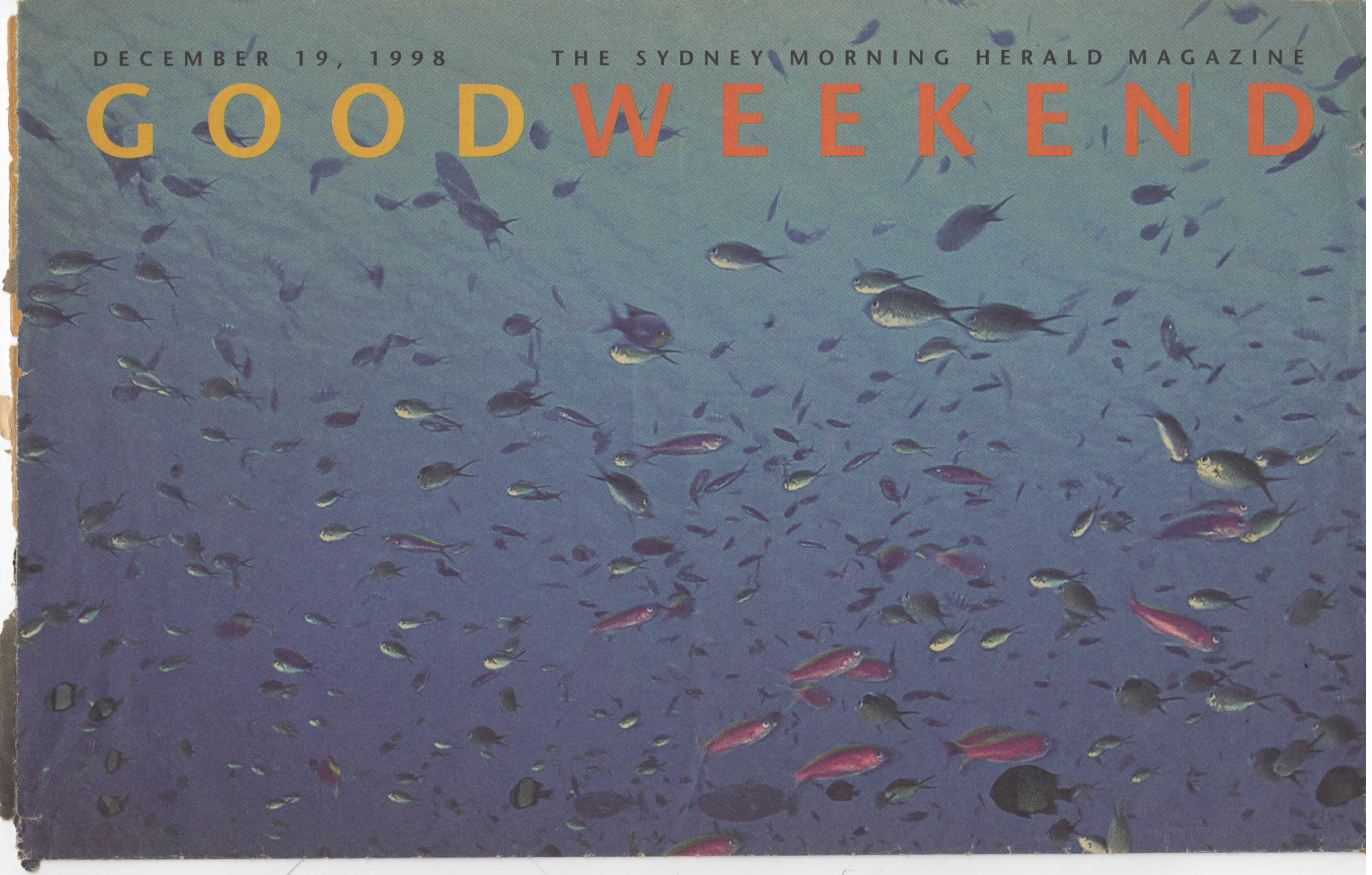
"This the real test — we have a large part of the world's corals which have been bleached," he said. "Those which come back and those which don't will tell us a lot about the effects of coral bleaching.

Reef expert Gregor Hobson said Australia, in particular North Queensland, played a vital role in ensuring the survival of the world's reefs.

The Great Barrier Reef's status as the largest and healthiest reef system in the world makes it an ideal role model for other countries, he said.

DECEMBER 19, 1998 THE SYDNEY MORNING HERALD MAGAZINE

GOOD WEEKEND

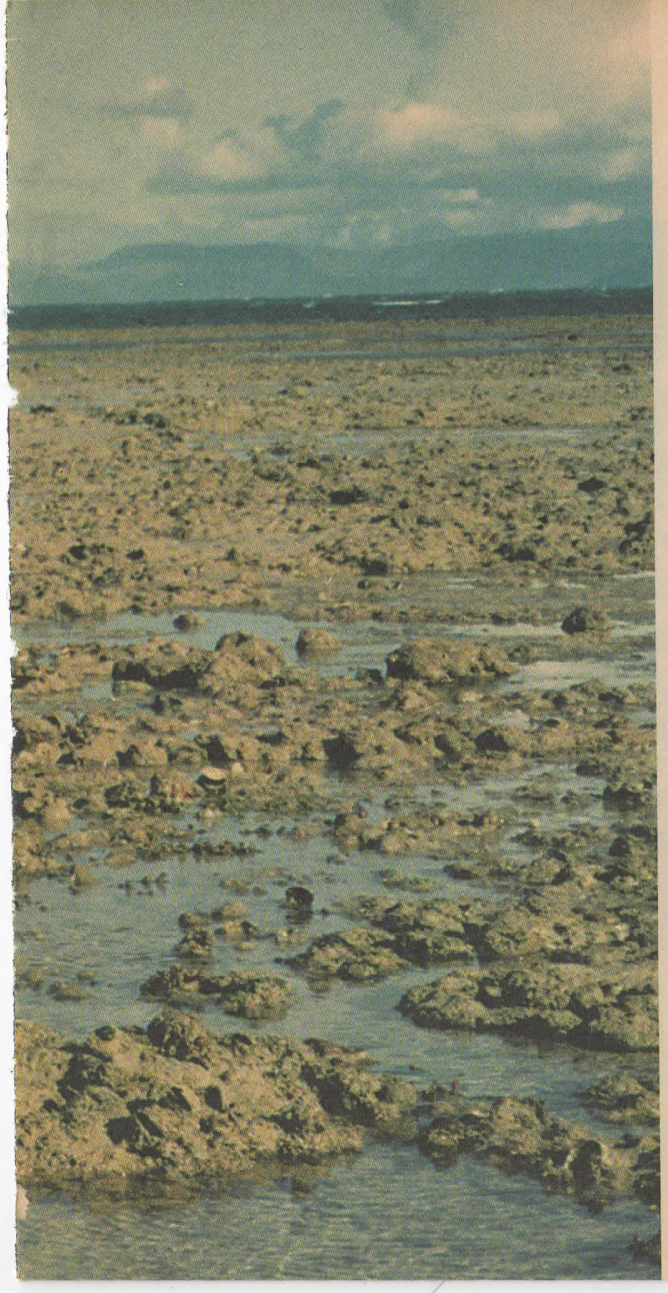


All we want for Christmas is a *great* Barrier Reef

Murray Hogarth on how we're quietly killing our pride and joy

Not waving drowning

It was threatened by the crown-of-thorns and Joh Bjelke-Petersen, but then came World Heritage listing and scientists told us the Great Barrier Reef was safe. Now, it seems, they were in denial. Leaked documents and damning photographic evidence reveal how we are carelessly killing off the most magnificent coral fields in the world. **Murray Hogarth** reports.



dismissed Goreau as an alarmist who uses fear to spruik for his Global Coral Reef Alliance. Late last month, Goreau came to Australia for an international symposium in Townsville, where he presented his latest evidence of dramatic threats to reefs everywhere from rising sea temperatures.

This year's temperatures have been the hottest recorded and the world's reefs are in trouble. As Goreau has been predicting for nearly a decade, corals are being maimed and killed as never before in human memory. Just a 1°C rise in average maximum water temperatures for three weeks can be lethal. The Barrier Reef has suffered unprecedented "bleaching", as the phenomenon is known, but it still escaped lightly compared with Indian Ocean reefs. In the Maldives, where reefs underpin the whole economy, up to 90 per cent of corals have died. In Vietnam's waters, a thousand-year-old giant coral colony bigger than a bus has been killed.

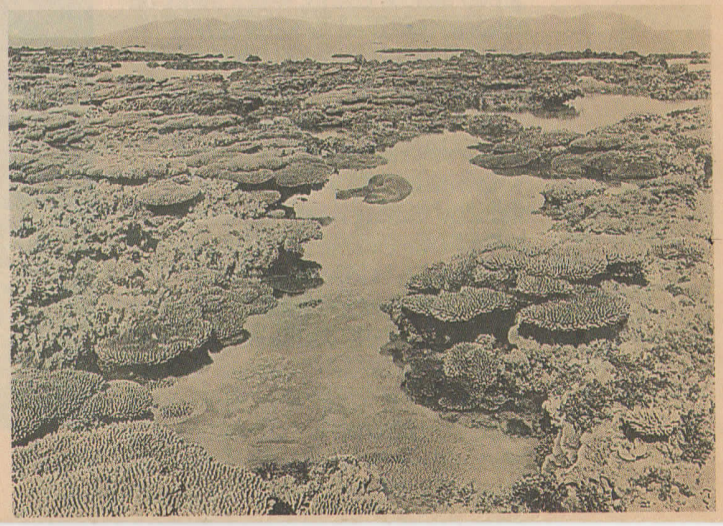
The reefs' nadir was 1998, the International Year of the Ocean, which followed the Year of the Reef.

Satellite data from the United States National Oceanographic and Atmospheric Administration shows a clear warming trend in sea surface temperatures since 1982, and a soon-to-be-published study forecasts rises of up to 5°C in tropical waters over the next century.

Around Townsville, water temperatures reached an unusually hot 32°C in February this year. The heat followed dramatic floods in January, which caused a major drop in salinity levels in local waters. Both these stresses contributed to the bleaching, whereby coral formations turn translucent white and sometimes fluorescent pinks and blues. The stress reaction involves coral polyps, which are animals, expelling microscopic plant cells, called

off Port Douglas revealed that extraordinarily low levels of nutrients such as nitrogen and phosphorous are crucial if beautiful hard corals are to outgrow comparatively ugly algae. But Bell, too, was branded an alarmist by those he calls the "Coral Club".

Recently, he has found that elevated phosphorous levels feed toxic blooms of microscopic blue-green algae called Trichodesium. The Trichodesium then draws nitrogen in massive quantities from the atmosphere, adding to that already flowing into reef waters from sewage outfalls and run-offs from farm and grazing lands. "It's like having fertiliser factories in the water," says Bell. With the extra nitrogen, other algaes grow. And, in a vicious cycle for corals, more algae means warmer water. "You have this animal that likes living in clear water," says Bell, "and suddenly it is living in semi-diluted sewage. The foundation to life on the reef is the algae. If you disturb the foundation, the whole thing will topple."



Great Barrier grief: (opposite) the reef flat around Stone Island in 1994 and (below) the same area, with coral thriving, in 1892.

PETER BELL; WILLIAM SAVILLE-KENT

TOM GOREAU IS A BRASH NEW YORKER, the enfant terrible of international coral science who has been warning for years that the world's reefs are doomed. He has been branded an extremist and his warnings have gone unheeded. Until now.

As a child, Goreau was surrounded by what he sees as the now-fading splendour of Australia's Great Barrier Reef. His grandfather, celebrated *Life* magazine photographer Fritz Goro, took the first underwater photographs of the reef, as well as the first complete aerial shots, from an RAAF plane in 1950. And in the 1960s, Goreau's father, also called Tom, revisited the site of an early reef expedition with legendary British marine scientist Sir Maurice Yonge, who first came to study the Barrier Reef in the late 1920s. "So I grew up with photographs of the Barrier Reef which precede those of all Australian reef scientists and which they are largely unaware of," says Goreau.

Most of those Australian experts have hitherto

zooxanthellae, which inhabit their cells. Normally, there is symbiosis between plant and animal: the plants feed off polyp wastes and create food for the animals by photosynthesis.

This partnership has built the entire Barrier Reef over the past 7,000 years, but plant and animal cannot thrive apart. Sometimes coral recovers from bleaching, taking back the zooxanthellae. But often it dies. Nearly 70 years ago, Sir Maurice Yonge described bleaching as a natural event in Australian waters. But that was bleaching on a small, localised scale, such as in an overheated tidal pool. Mass bleaching was first observed in 1979-80, has occurred regularly since and hit a disastrous peak in this year's record heat. Goreau believes that if it keeps getting hotter due to human-induced global warming, as predicted by a panel of 2,500 top climatologists, then reefs are doomed. "The catastrophe is going to hit," he says.

DR OVE HOEGH-GULDBERG IS A LEADING REEF researcher from the University of Sydney who, like Goreau, has been viewed with suspicion by his more conservative peers. But this suspicion is abating, precipitated by this year's outbreak of bleaching. "There has been a watershed in the last few months," says Hoegh-Guldberg. "People had been trying to be careful and cautious and so forth. But now there is a sense of urgency, I think, because of the rate of change." Hoegh-Guldberg, Goreau and even their former critics see coral reefs as "canaries in the coal mine", foreshadowing the wider impacts of a warming world.

But global warming is only one of the threats to the reef. Rising nutrient levels caused by run-off from agricultural activity on land have killed much of the inshore hard corals. A decade ago, engineer Peter Bell's research on the Low Isles

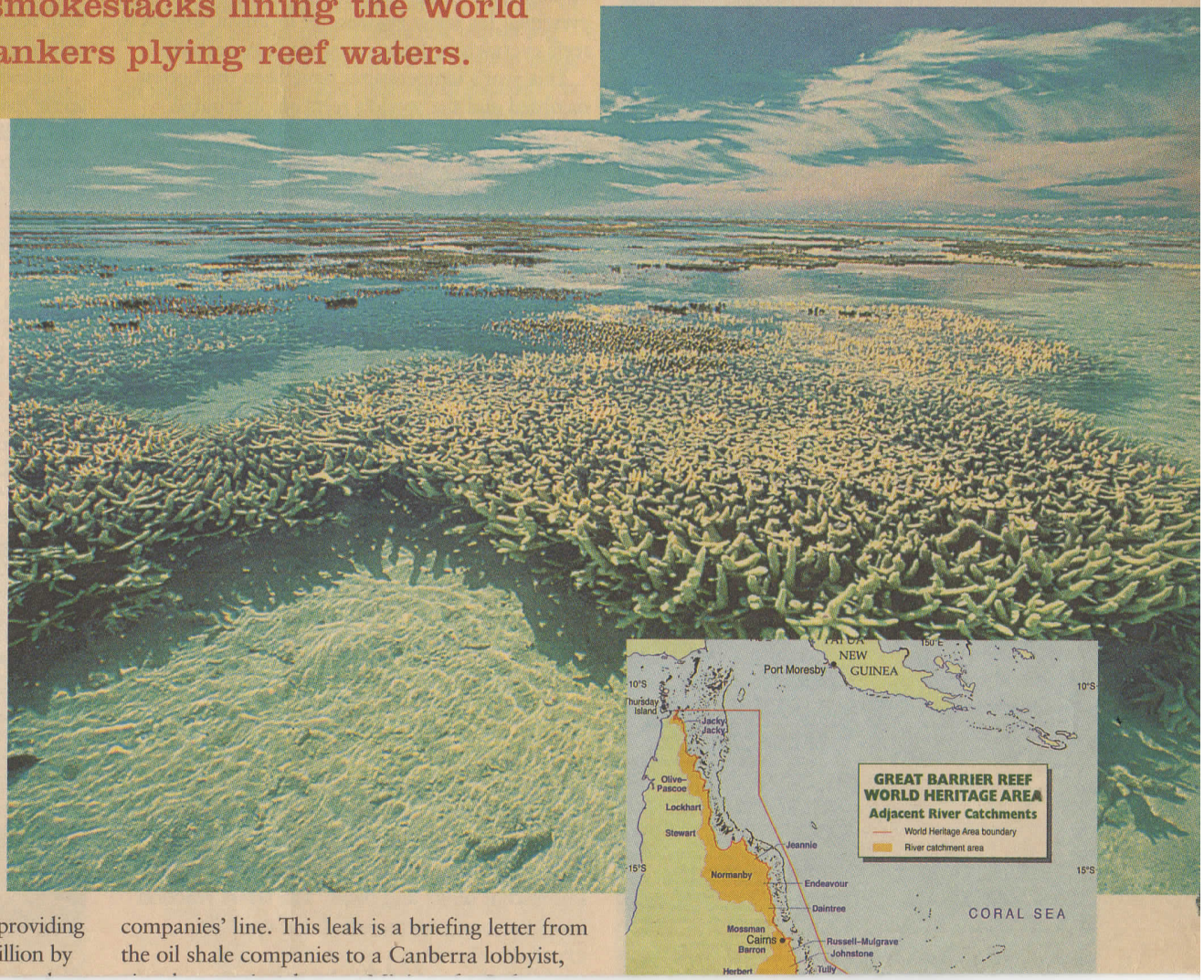
ONE FACTOR IN LAST SUMMER'S UNUSUAL HEAT WAS El Niño, which produced weather extremes around the world. The latest official global-warming predictions, which include air-temperature rises of 2°C within 50 years, have El Niños becoming more frequent and more severe. The arch villain in this global-warming scenario is the burning of fossil fuels such as oil and coal, which causes carbon dioxide and other so-called greenhouse gases to build up in the atmosphere. As the air gets hotter, so does the sea.

Bizarre and perverse, then, is a proposal to develop a massive new fossil fuel industry bang-slap on Queensland's reef coastline. Buried on the shore, sometimes extending into the water and even into the Great Barrier Reef World Heritage Area, are huge deposits of oil shale. The volume of the resource, and the value if it is mined, is mind-boggling – potentially 29 billion barrels of oil worth an estimated $500 billion. It's the equivalent of another North Sea at a time when known oil-well reserves are being forecast to run down by 2050. That's about when Goreau fears that coral reefs will be gone.

Exploiting oil shale could mean prolonging our lazy dependence on petroleum, just when even giant oil companies such as BP are moving in a big way into renewable solar power technology. And on the basis of proven technology, oil from shale is the most greenhouse-polluting fossil fuel of all. It's hardly surprising, then, that Queensland's unique juxtaposition of vast oil-shale reserves and vast coral fields has become a focus of international concern for the future of the reef.

Although the mining proposal came to international attention only this year, two companies, Southern Pacific Petroleum and

By 2007, oil shale companies want a huge plant, producing 85,000 barrels a day, with smokestacks lining the World Heritage coastline and tankers plying reef waters.



In deep water: (right) the telltale signs of bleaching on reef coral; (inset map) the biggest World Heritage area on earth.

Central Pacific Minerals, have been fossicking around oil shale for nearly three decades. Their corporate patriarch, Sir Ian McFarlane, is a relic of the Queensland of Sir Joh Bjelke-Petersen, a knight of the long-serving National Party premier's realm. McFarlane saw black gold in shale when Bjelke-Petersen was urging others to drill for oil on the reef itself.

Several years ago, McFarlane's twin companies were joined by Canadian group Suncor Energy, which mines oil from tar sands on its home turf in Alberta. In June this year, *The Sydney Morning Herald* published extracts from leaked government documents which revealed alarm among reef authorities about a new kind of oil industry starting on the coastline.

When the Queensland and Federal governments cleared the way five years ago for a $250 million oil shale "pilot plant" near Gladstone, no-one consulted the official guardians of the reef, the Great Barrier Reef Marine Park Authority (GBRMPA). The first oil is expected next year, with the governments providing grants and incentives worth up to $244 million by

companies' line. This leak is a briefing letter from the oil shale companies to a Canberra lobbyist,

production plant, producing 85,000 barrels of oil a day, with smokestacks lining the World Heritage coastline, tankers plying reef waters and mining operations to dwarf even Central Queensland's vast coal mines. Ultimately, they envisage producing 1.5 million barrels a day at a series of sites.

Naturally, a battle royal is brewing between the companies and the environment movement, which has been looking for causes to energise its troops and revive flagging fortunes. What better than a massive new fossil fuel industry right next to an already beleaguered natural wonder of the world?

On the conservation side, Greenpeace is leading the charge, targeting Suncor in Australia and Canada, and fighting the public relations war on battlefields such as last month's United Nations climate change summit in Argentina. Oil shale is scheduled to hit major production just as Australia and other developed nations have to live up to the Kyoto Protocol to reduce greenhouse pollution.

The companies know they have a fight on their hands. They are countering with a climate change strategy, including the promise of new technology to reduce greenhouse emissions from oil shale production and a major tree-planting trial to "capture" the main global warming gas, carbon dioxide. They also have hired top environmental consultants from Ecos Corporation, in the shape of former Greenpeace International executive director Paul Gilding and former high-profile ABC Television environment reporter Alan Tate. These green-savvy guns-for-hire contend that oil shale dollars will help fund a brave new world of sustainable energy.

A recent document leaked to the Democrats, who also obtained the first evidence of the Marine Park Authority's internal alarm over oil shale, shows the

Science and Resources, Senator Nick Minchin, and "other targets". Their message will be one of environmental responsibility and economic bounty, including 5,000 jobs and a $15 billion improvement in the balance of payments over the lifetime of just the first oil shale mine. The Commonwealth has responded to the embarrassment caused by the first leak with an exhaustive Australian Federal Police investigation to find the perpetrator, presumably within Environment Australia or the Marine Park Authority.

At the same time, authority chairman Dr Ian McPhail warned his staff that public servants face jail sentences if they are caught leaking. So what about openness and transparency in management of one of the world's natural wonders? McPhail is unapologetic: "I did make it clear that if you are professionals and you take the king's shilling, then matters of government should remain confidential. A pattern of leaks puts an organisation at serious risk inside government. It will be excluded."

At the Townsville symposium last month, scientist after scientist told GOOD WEEKEND that GBRMPA had been instructed by the greenhouse-sensitive Federal Government not to link coral bleaching and global warming. McPhail denies ever receiving such an edict. That week, just as Goreau and other world experts were preparing evidence for exactly that link, McPhail put out a major press release proclaiming the reef is in "good shape" and blaming bleaching on the 1997-98 wet season.

"My position is, it is not for us to make those linkages," says McPhail.

AT THIS POINT, THE JOURNALIST SHOULD declare an interest. For me, the oil shale controversy stirred memories of being young on

the Queensland coast. I grew up in Bundaberg, at the southern end of the Barrier Reef, near an oil shale deposit at Lowmead to the north. As a child, I holidayed on reef islands, snorkelled in azure lagoons on the outer reef and marvelled as so many before and since have done at the life and colours. As a young man, I fished the remote Swains with my father. I sailed in a yacht race around perilous Lady Elliott Island in the dark of night. I even dallied romantically on the national park beach of Lady Musgrave, a true coral cay.

In those days, I never dreamed anything so big could be so vulnerable. Many people think the same way. The reef is the planet's biggest World Heritage area. It has more than 2,800 coral reefs, spread over 350,000 square kilometres. There are hundreds of islands, the vast inner-reef lagoon and a swath of continental shelf. There are about 350 coral species, 1,500 species of fish, 4,000 species of molluscs, and many other flora and fauna.

My awakening to the Barrier Reef's growing peril began nine months ago, before oil shale hit the news, at the height of the bleaching damage in Australian waters. I was flying in a light plane out

of Townsville, trawling for a reef story. It soon became apparent that times are turning bad for the world's reefs. Even for the greatest of them all. From take-off, the magnificent reef vista opened up. But during two hours in the air, over sea, islands and the tropical mainland, my coral comfort zone was smashed. It was a trip that tourism operators, who loathe media coverage of bleaching and other reef damage, never want you to take.

Within sight of the Marine Park Authority's Townsville headquarters is the once-magic Nelly Bay, on Magnetic Island, scarred by the bulldozing of a green headland a decade ago to build a

slower and weaker coral growth, at a time when the forces that damage corals are becoming more severe and more frequent. "I think it is the underwater equivalent of acid rain," says Done.

But the bleaching is bad enough. If Tom Goreau and a growing body of scientists are right, the bleaching alone is enough to kill most reefs stone-dead within 50 years. One of Done's PhD students, Kristen Michalek-Wagner, reported that, beneath the water, parts of the Great Barrier Reef were like a "graveyard". Michalek-Wagner, a young German, had come from Hamburg hoping to study life, not death and decay. In Europe, she says, "everything is dead and you just study how dead it is".

Another Done assistant, Dr Katharina Fabricius, also comes from the Hamburg school of dead ecosystems. Her work echoes that of Peter Bell at Low Isles, charting the decline of fringing reefs along the Queensland coastline, with hard corals being replaced by faster-growing soft corals and algae fed by rising nutrient levels. Coral gardens found near the coast when the reef was more pristine are now found only on outer reefs.

If you think of the reef as an underwater forest, then losing the hard corals to algae is like cutting out old-growth diversity and replacing it with a plantation monoculture. Nutrient and sediment levels in the Barrier Reef lagoon, that vast waterway between the coast and the outer reefs, are up fourfold on pre-European settlement levels. Many inshore reefs are almost gone.

Our flight crossed the lagoon where the nets

Robert Hill could "read it". In the meantime, the spin doctors of the fishing industry selectively released more positive aspects of the report to the media.

Aboard the little Cessna, our route took us over the busy shipping lane, trafficked by everything from drug runners to tankers, at constant risk of oil spills. Then we passed over Bramble Reef, where sea life is struggling to recover after being depleted to the point of exhaustion by over-fishing, including by Townsville's recreational anglers. For two years, it has had to be closed to all fishing, for replenishment. After Bramble, the plane banked and turned back to a lush green coastline pockmarked by human development: the highly controversial Port Hinchinbrook resort project, sprawling aquaculture farms for prawns, expanding canelands amid shrinking wetlands, a sugar port. And shortly before we landed, the huge Yabula nickel refinery with its smokestacks and near-satanic black tailings pond.

Days later I moved north to Port Douglas, the tourism hotspot of Far North Queensland, where huge catamarans and dive boats take thousands of visitors to the reef each day and dump their sewage in the sea on the way home. It is a symbol of contempt for the reef environment, with onshore disposal long contemplated, but yet to be delivered.

AFTER A WEEK AWAY, IN TOWNSVILLE, CAIRNS and Port Douglas, I returned to Sydney and rushed to tell family, friends and anyone who would listen that I had seen a vision of how the reef could die next century. In my children's lifetime. The first editor I pitched the story to was interested, but dubious. He'd heard, and read, and watched too many "the reef is doomed" stories. Scientists, too, have been made sceptical by the

marina breakwater. The bare earth still stands out, long after the developers abandoned the project.

We flew on, to corals turned ghostly white by bleaching. "Anything you can see from an aeroplane is pretty significant ecologically," observed Dr Terry Done, a veteran of Australian reef research, who is now president of the International Society for Reef Studies.

Later Done told me of his own reef awakening early this year. "For years I have been the scientist who will say, 'She'll be right. It is very big,'" he confessed. Now his cosy optimism is gone, his confidence shaken. He worries about perils so large, so insidious, that even size doesn't matter. "There is a great element of denial among everyone," Done warns. What he sees is a vision of the reef's demise, fuelled by the cumulative impacts of all the forces – natural and human-influenced, in the sea, on the land and up in the air – that can hurt reef ecosystems: outbreaks of the coral-devouring crown-of-thorns starfish, powerful cyclones, huge floods, giant irrigation dams for cane and, more recently, cotton farming, El Niño, the barbed hooks and scything nets used in fishing, a million tourists a year, the developers who build resorts and marinas. And global warming.

Until recently, Terry Done was blasé about global warming and greenhouse gas pollution of the atmosphere. He contributed to the UN's Intergovernmental Panel on Climate Change, basically telling its 2,500 scientists not to worry about reefs. "I had no idea," he recalls. "I was saying 'a bit more water, she'll be right'." Now he's embarrassed, and not just because of bleaching.

His wake-up call came when French scientist Jean Pierre Gattuso postulated that increasing levels of carbon dioxide in the atmosphere will reduce calcification rates in tropical waters. That means

BILL CREW/ODYSSEY

so many submarine harvesters, stirring up the growing load of sediments. The waters are often turbid and tropical beaches get slimed. It's clearfelling underwater, say conservationists. They want trawling stopped, just as rainforest logging was when the neighbouring Wet Tropics World Heritage Area was declared a decade ago. But what has been happening under the water has been out of sight, out of mind.

Last month, however, the CSIRO completed a $5 million, five-year study for the Marine Park Authority of trawling's impact on the lagoon and inter-reef areas of the marine park's far-northern region. It shows that, for each tonne of prawns netted, 6-10 tonnes of "bycatch" such as small fish, crustaceans, even endangered sea turtles, are caught and die. Each sweep of a trawl net removes between 5 per cent and 25 per cent of seabed life, especially sponges and flower-pot corals. Trawling is changing the composition of life in an area that is home to up to 1,000 life forms. Eighty per cent of the marine park is officially open to trawling; but 40 to 50 trawlers regularly operate illegally even in one of the marine park's most important "green zones", which are meant to be fully protected.

Instead of making the full report on trawling public immediately, the Commonwealth held up its release for weeks so that Environment Minister Senator

the crown-of-thorns starfish, which is cited by some as a reason to avoid being too alarmist about bleaching. Terry Done, for example, speaks of his earlier aversion to "conservationists and scientists who see a bit of dead coral and say that the sky is falling". (Now, Done fears, the sky is not so much falling as changing composition for the worse.)

Faced with doubts, I took a reality check. Professor Frank Talbot, of Sydney's Macquarie University, a grandee of reef science in Australia, is a founder of two major research stations (at One Tree Island and Lizard Island) with an outstanding international reputation. While he seethed about the Hinchinbrook resort development I had seen during my flight, he was relaxed about the reef as a whole.

Human activities offshore and on: (above) scuba divers off Port Douglas; (below) the massive Stuart oil shale "pilot" plant on the edge of the reef at Gladstone.

"It's so big," he explained. For a while, my reef story went on the journalistic backburner.

But then the flame started to burn hotter again. There was a tip-off that UNESCO and World Heritage authorities based in Paris were growing increasingly concerned about the reef's safety. Then came the oil shale leak and, in September, Frank Talbot and two other eminent reef experts penned a confidential letter to the World Heritage Bureau in Paris, pleading for international intervention. They sought a field mission to Australia to investigate allegations that the Federal and State governments, and the Marine Park Authority, were failing in their duty of care. "Unless this is done," the letter ends, "and the governments are made aware that their conduct is under scrutiny, the bureau will be presiding over the slow death of the greatest exemplar of coral reefs on the globe."

"There is not the passion there. You do not feel these people are seriously trying to protect this reef. They do not do battle. They are bureaucrats."

THE ORIGINS OF THE AUTHORITY AND THE marine park lie in the 1970s, when the Whitlam Labor Government vowed to protect the reef from the oil-drilling ambitions of maverick premier Joh Bjelke-Petersen, who owned shares in one of the exploration outfits. To this day, 26 areas down the coast remain outside the marine park, as reserves for development.

Canberra's founding vision was one of conservation being the "paramount aim" but, over time, a doctrine of "multiple use" took over.

A real conservation agenda, meeting the scientific precautionary principle of not undertaking activities or developments, unless it is certain they will not harm the environment, would restrict nearly every human activity east of the Great Dividing Range. And on Queensland's politically swinging coast, with its long line of marginal State and Federal seats, the chance of restricting development in water catchments for the reef appears non-existent. Indeed, the politics of the reef territory are so tough that major political parties tread carefully. Only the Democrats, whose focus is on Senate seats and big-city votes, run hard on defending the reef. Less than 5 per cent of the entire park is in protected zones analogous with land-based national parks, and only oil drilling and mining are banned outright in the rest.

Global warming aside, the greatest threats of all are on the land, beyond GBRMPA's often timid reach. The authority likes to promote itself as a role model for marine park management everywhere. But, like the reef, its survival is uncertain. The Federal Government has slashed its funding, it is often ignored by the Queensland Government and it is regularly attacked by the powerful tourism and commercial fishing lobbies.

When the Howard Government came to power in 1996, GBRMPA was on a hitlist. It has survived, but lost its spirit as well as funding. The Association of Marine Park Tourism Operators, mainly representing big Japanese-owned tour boat companies, attacked GBRMPA last year in a letter to the Federal Government. The authority was a "bureaucratic monolith" that could be "significantly downsized", the letter said. Others believe it is under-staffed, under-powered and badly under-funded.

Authority chief Ian McPhail says that a staff of 110 responsible for an area bigger than many nations is hardly a monolith. Even among those scientists and conservationists who would prefer to be the authority's friends, it has harsh critics. Jeremy Tager, director of the Townsville-based North Queensland Conservation Council, likens GBRMPA's malaise to the organisational equivalent of "battered spouse syndrome".

Plummeting morale and a staff brain drain over recent years are a common complaint. Insiders speak of political interference and of scientific monitoring that does not address the real problems. "There is not the passion there," says Frank Talbot, the reef veteran. "You do not feel these people are seriously trying to protect this reef. They do not do battle. They are bureaucrats."

The guardian of the reef is like a tired swimmer in trouble in big surf. It's trying to keep its head above water, but it keeps slipping under, the waves are getting bigger and tricky new currents are appearing.

Nearly all the problems faced at the authority's

inception 21 years ago still exist. Many have become bigger. Others refuse to fade.

There are still prospects for oil and gas exploration onshore, immediately adjacent to the reef, such as in the Laura Basin on Cape York. New technology allows wells to be drilled from land, horizontally, for more than 30 kilometres offshore. And Queensland is pushing for a giant $3 billion gas pipeline down the entire coast, bringing cheap new energy from Papua New Guinea to fuel more coastal industry.

The old bogey, the crown-of-thorns starfish, is again massing in northern reef waters and the third major outbreak since 1960 is expected.

Last year's conservation coup was meant to be the creation of special dugong protection zones after a dramatic fall in numbers of the threatened sea cows, blamed in part on gill-net fishing and shark nets. But dozens more dugong are turning up dead on beaches this year.

It is environmental groups, rather than GBRMPA, that are trying to use the Commonwealth's own laws protecting threatened species to upgrade reef protection. The Humane Society International, with more than four million members in the US, is seeking to have both trawling and cane farming listed as "key threatening processes" for endangered reef-zone species. Environmentalists and recreational fishermen are at loggerheads with the sugar industry over at least 30 fish kills this year and a growing incidence of "red spot" disease, both being blamed mainly on acid sulphate soil run-off from cane farms in particular. But, at the same time, huge expansion of the sugar industry in the coastal belt is being pushed by a $200 million restructuring package funded by Queensland and the Commonwealth.

A major international report called *Reefs at Risk*, released this year by the World Resources Institute, estimates that 29 per cent of the marine park's reefs, covering 13,700 square kilometres, face a medium risk and 1 per cent (600 square kilometres), a high risk. But GBRMPA's enduring mantra is that the reef is "in good shape and in good hands".

Meanwhile, major new threats to the reef environment keep emerging. There is the live fish trade, which targets the biggest and best of reef fish for Chinese banquets in Asia. The big-money trade's quest for maori wrasse, coral trout, barramundi cod and other exquisite fish has devastated reefs to Australia's north, where fishermen use dynamite and cyanide. In the past few years it has progressed down under, with only the Asian economic crisis keeping demand in check.

From around the world, including on the Barrier Reef, there are alarming reports of coral diseases previously unknown to science. Some are bacterial, some fungal.

Finally, there is the spectre of global warming, with its growing list of perils for reefs: more powerful cyclones to pound them; more frequent and more intense El Niños (and the counter-cycle La Niñas) bringing extremes of weather including more floods; rising sea-surface temperatures; and even reduced calcification rates in the water. "Reefs are affected by everything," says Tom Goreau. "They are the ultimate downstream ecosystem and they are the best test of ecologically sustainable development."

After I interviewed Ian McPhail, he sought another meeting to clarify several points. He'd been "a bit on the back foot" in the first round, he said. He was worried about who I was listening to.

"I am not in the business of skilfully managing the slow degradation of the Great Barrier Reef," he insisted, unprompted. "I believe in the past five years we have put the conservation of the Great Barrier Reef up on a high pedestal."

IN JUNE NEXT YEAR, THE UN'S WORLD HERITAGE authorities will assess whether that pedestal is high enough. As with Kakadu National Park and its Jabiluka uranium mine controversy, Australia's management of the reef is now under review by the planet's masters of conservation. A report on the reef by the UN's formal technical advisers in Australia, obtained by GOOD WEEKEND, lists a litany of threats: trawling, the live fish trade, aquaculture, coastal development (including on islands), neighbouring land use, dam construction, pollution, oil spills, oil shale mining, crown-of-thorns starfish and global warming.

The report cites wide support for more high-protection areas, identifies a "critical need" for more management resources for the Marine Park Authority, and calls for control over inappropriate activities and development on land. It warns of inadequate scientific knowledge and monitoring, poor enforcement, and jurisdictional confusion which allows issues to "slip between the cracks".

It seems the world has stopped believing that all is well with World Heritage icons entrusted to Australia's care. Yet for all its problems, the Barrier Reef almost certainly is still the best-preserved, best-managed coral community of any great size in the world. The shame is that this is cold comfort in a warming world, where most reefs are already badly damaged and many are near death. ■

Murray Hogarth is environment editor for The Sydney Morning Herald.