

PROLOGUE

## Last days of an ocean system

Tim Flannery was barefoot the evening I met him, pants rolled up to below his knees. It was dusk and we had found each other in the unlikely town of Whyalla, South Australia, where, it is said, the outback meets the sea.

Our meeting was sheer serendipity. The two of us had happened to fly into this remote town of 22,000 on the same plane the night before and he had been at meetings all day with the town's steelmaker, continuing his international *tour de force* of explaining global climate change to the public, business leaders and politicians.

His book *The Weather Makers: How We Are Changing the Climate and What It Means for Life on Earth*, Al Gore's book and movie *An Inconvenient Truth: The Planetary Emergency of Global Warming and What We Can Do About It*, and the report by Sir Nicholas Stern, the former chief economist of the World Bank, on the financial consequences of ignoring climate change have been the one-two-three punch that has convinced the public that global climate change is more than, well, hot air.

Their combined effect—in concert with Hurricane Katrina's devastating tear through New Orleans in August 2005—has been remarkable. As I researched this book across five continents and

over two and a half years, everyone I spoke with could pinpoint the moment that the public discourse changed from whether or not global climate change was real to what humanity needed to do about it: the third quarter of 2006, after the cumulative effect of Katrina, Flannery, Stern and Gore.

So Flannery, an Australian ecologist, is a hero to people like me who also write books about the environment. I had been hoping to meet him because he got it so right.

Plus, Flannery has done three things that other brilliant scientific minds rarely do: he has been able to put together an integrated picture of what the science is telling us, explain the implications of that big picture and then help people hear the story of those implications.

He is, in effect, a prophet who is taken seriously, who somehow happened to show up at the right time and be able to tell his story in the right way. A historically rare entity.

When we met he was longing to walk on the beach, so out we went to the sandy shore of the Spencer Gulf that runs in front of the Foreshore Motor Inn, Whyalla's finest accommodation, where the steel company had put him up.

I talked and talked, telling him about this book, the stories of my travels around the world, the scientists I had met, the questions I still had, and, above all, why it matters so much to me that all the things I have found out become part of this new, informed public discourse for which he helped lay the groundwork.

I told him of my worries.

The global ocean makes up 99 per cent of the living space on the planet, thanks to its immense depth. If you add up all the land surface and the narrow band of the atmosphere that supports creatures who breathe air, the total represents just 1 per cent of the areas where life can survive on the planet. The rest is in the ocean, covering more than seven-tenths of the earth's surface.

Even more significant than the ocean's breadth and width is its depth, or third dimension. That total volume, with its immense biological importance, is what I came to think of as the deeps, both the source of life and the future of life on the planet.

The issue is that all over the world ocean scientists, in groups of specialists who rarely put their information together, are finding that global climate change and other human actions are beginning to have a measurable effect on the ocean. The vital signs of this critical medium of life are showing clear signs of distress.

That's because roughly a third of the carbon dioxide that humans are putting into the atmosphere has entered the ocean. In addition, about 80 per cent of the extra heat being created by climate change has been absorbed by the ocean.

These two phenomena—carbon dioxide and heat—are changing the ocean's acidity, patterns of saltiness, temperature, volume, ice cover, function within the planet's carbon and oxygen cycles, and possibly the physical structure of the currents as well. And these are just the ones we happen to know a bit about.

This change is happening all over the world. And this is having a profound effect on many of the creatures that live in the ocean. At the same time, our search for food from the sea has resulted in the removal of massive quantities of creatures from the global ocean. In itself, that's a problem. And it's exacerbated by the changes we're also causing through carbon dioxide and heat, because life in the sea helps regulate the sea's physical and chemical properties. When we remove so much life, we're also removing one of the ways in which the ocean can keep its systems stable.

This is so important—and so different from the way that most of us see the issue—that some scientists I have met argue that instead of calling this the age of 'global climate change', we

should call it the era of ‘global ocean change’ or ‘marine climate change’. These terms are both much more accurate and more worrisome.

The ocean is built to withstand change. It has layers of safeguards that the atmosphere and the land systems do not, and yet even these are being breached. It is a larger and more serious problem than atmospheric change.

However, we are not hearing much about it, or about the implications for life on the planet—not just human life and civilisation, but life in general. We hear from time to time about overfishing, or about the cities that would flood if the sea level rose, or about coral bleaching, but rarely everything put together.

The first scientific attempt to map the human effect on the world’s ocean came out in the journal *Science* in February 2008. It found that there was no area immune from human influence and warned of the cumulative effects on the global ocean of so many contiguous elements of change. The first major international scientific conference to bill itself as being about the intersection of climate and oceans was in April 2008 in Hanoi; the fourth Global Conference on Oceans, Coasts and Islands. Its recommendations about what to do will not even enter public discourse until 2009.

The fate of the sea is not part of formal global discussions about carbon dioxide reductions. Any cohesive plan to put together these pieces of information about the ocean and protect the ocean as the main medium of life on earth is in its infancy.

One of my greatest shocks as I researched this book was that as I travelled from country to country, topic to topic, research boat to research boat, and told each new group of scientists what I had been finding, each group was surprised. In other words—and with some notable exceptions—even some of the planet’s top research scientists didn’t have the full picture of what’s going on. Each has a specialty, isolated from the larger context for the most part, without a systemic understanding of

how the pieces fit together. It reminds me of that old joke about the blind philosophers, each of whom has their hand on a piece of an elephant and is trying to describe the elephant from the piece rather than the whole. This was the state of atmospheric climate change science about twenty years ago.

Tim Flannery is a thoughtful, soft-spoken man who chooses his words carefully. Like so many biologists, he notices without effort tiny details of his environment that most of us overlook.

As I spilled my tales he became fascinated with some rare blue swimmer crabs that had washed up on the beach, and he would bend down swiftly every now and again to pick one up and examine it. In my pauses he gave elegant natural history lessons on the mangroves we could spot from the beach and how isolated they were from other patches of the world's mangroves.

He stopped to chat with some men who were fishing for sport, peering into their buckets and joking with them. His pockets bulged with pieces of giant squid cartilage half the size of boomerangs, marked by the teeth of dolphins. He handed me one or two, wondering out loud whether the dolphins ate the squid or just played with them.

Offhandedly, almost, he started to talk about the ocean, assembling disparate bits of information from his vast mental library.

About 250 million years ago, during the time known as the Great Dying at the end of the Permian period—the biggest mass extinction the world has yet known—the ocean's oxygen ran out. There are a couple of theories about why this happened, but a leading candidate is that the surface layer warmed up enough and became salty enough to disturb the currents. Currents feed oxygen from the atmosphere into the ocean and move nutrients around. When the oxygen vanished, most life on land and in the sea—more than 90 per cent of the species then alive—died.

The point of the story, he said, is that it is clear that the ocean contains the switch of life. Not land, nor the atmosphere. The ocean. And that switch can be flipped off.

We know it's happened in the past, he told me. We just don't know the trigger.

Flannery pointed out that oxygen levels in the deep waters of the Southern Ocean around Antarctica have dropped about 3 per cent in the past decade. He continued, building his case methodically. The atmosphere is 500 times smaller than the ocean, by mass, and during his lifetime of just a few decades, the atmosphere had sustained three separate and severe man-made assaults: acid rain, the ozone hole and increased carbon dioxide levels.

Those assaults had taken place when the polluting substances could be measured in the atmosphere in parts per million. Today, changes to the composition of the atmosphere can be measured at levels of parts per 10,000—two orders of magnitude larger than those earlier catastrophes.

Flannery stopped, breathing in the salty sea air, marvelling at the sun as it set over the very ocean we were discussing. 'Look at the sky,' he said, pointing to the glorious oranges, pinks, purples, blues, a huge smile on his face. 'Look at the colours.'

I still wasn't getting it. I understood the separate ideas, but not the larger message. The point, Flannery said as we started walking back to the motor inn, is that changes to the atmosphere are serious, as his own book had shown, but that changes to the ocean are far more so. The ocean is a bigger system. It's more critical to the life support of the planet. And the changes that once affected only the atmosphere are now big enough to impact on the ocean.

He told me that I was documenting the last days of a system. Humans are now interfering with the most basic elements of that system.

Keep going, he adjured me as we reached the inn's lounge, where he bought me a fortifying glass of Australian white wine.

'Just keep going,' he said, still barefoot, 'if for no other reason than that I need to read this book.'

I think often of Flannery and our walk on the beach at Whyalla, now that I am back in Canada trying to make sense of what I have learned and put it into this book.

This book did not start out to be the chronicle of a dying system or, to put a different face on it, one that is switching. It started because I became fascinated with the ocean as a global system while I was working on my last book, which was about environmental problems on land.

I was on the final journey of that book—on a research boat in the Galapagos—when I ran into Sylvia Earle. She is one of the world's most famous scientists, a marine biologist and deep-sea diver who revolutionised the way we understand ocean life by watching it where it lives rather than hoisting it up out of the water and examining it in a lab.

I was bunking with her on the ship, thinking about the black islands of the Galapagos and their amazing plants and animals. I still considered the ocean to be more or less a two-dimensional transport route with an amusing roster of animals near the surface. But since I am a journalist I started asking her questions about why she became a biologist. She answered me patiently. Finally, I asked: *But why a marine biologist? Why not look at creatures on land?* Because, she answered neatly, stopping me in my tracks, the ocean is where most of the life is.

I had never looked at it this way. Being a creature of land and a student of the land's life forms, I had never thought a lot about the ocean or the fact that life on land is utterly dependent on the life and chemistry in the ocean.

As I've discovered since, plankton produce half the oxygen we breathe or, put another way, every second breath we take. These microscopic creatures are the real lungs of our planet. The ocean controls climate and temperature and the carbon and oxygen cycles of the planet, as well as other chemical systems that give all living creatures life—including us.

Earle's concern then was the human tendency to use the ocean as an endless sewer and grocery store, dumping our waste in it and catching food recklessly. Even those few years ago, it was not clear that the ocean system was switching.

So I finished writing my last book and started reading up on the ocean. This was an act of courage. I have been afraid of water since I was a toddler and nearly drowned in an undertow on summer vacation. My parents, sitting on the beach a couple of metres from me, watched me go down and then bob up a couple of times before they realised that I was in trouble. My father dashed in and pulled me out, saving my life. I don't remember the incident, but sometimes I wonder if terror that strong and that primal is stored in the depths of the brain. Certainly it pounced on me at the most surprising moments while I pondered the fate of the sea for this book, and only while I was immersed in water.

Like so many through the ages, though, just as I feared the ocean, I was beguiled by it. Not just by its mystery or its backdrop for the collective human imagination, but by the fact that we barely even understand that it is a single, interconnected system, much less one so critical to our own survival.

At first I felt like an explorer, immersed in a growing understanding of the sheer physicality of the ocean: how the currents move and shunt heat and cold around; how the thin layer of molecules at the surface of the water breathes into a similarly slender layer at the bottom of the atmosphere, creating the chemical soup that allows life.

I read in awe of the complicated architecture of the deep ocean floor, where the earth's surface plates are dying and being born, and where the planet's largest mountain range—unseen by all but a handful of humans, and unimagined by most of us—runs like a backbone up and down the centre of the open ocean between the Americas on one side and Europe and Africa on the other.

It was a new, secret planet hidden in the world I thought I knew well, that I had spent the better part of a decade exploring and writing about. It was intoxicating.

At the same time, the Census of Marine Life began a billion-dollar worldwide exercise to figure out what lives in the global ocean—it was a pioneering human undertaking, aided by new techniques used to read each creature's DNA and trace its path backwards to the origins of life. Month after month new ocean creatures have been discovered, new clues mined about how life as it is now came to be and therefore, possibly, where it might go next.

Finally, though, it was the chemistry and physics of the ocean that captured me and held on. I am no chemist and certainly no physicist. My first degree is in English and Latin literature, and my second in journalism. But one book—which I found in Bocas del Toro, Panama, at the Smithsonian Tropical Research Institute's station there—seemed to reach out and grab me by the throat. It was *Air and Water: The Biology and Physics of Life's Media*, by Mark W. Denny.

Denny writes, crisply, that all living things on this planet live in one of two fluid media—either water or air. Of these, as I mentioned above, water is by far the larger, making up 99 per cent of the living space on the planet and home of at least half of the mass of life. This means that life is thicker on land and more spread out in the water.

Denny's book is about how the differences between air and water affect and constrain what types of life can exist in the two

media. You couldn't expect a hummingbird to live in water, he points out, or a fish to live on land.

'After all, many of the basic attributes of life—the size and shape of an organism, how it moves and reproduces, how it captures food, the nature of its sensory capabilities—differ in familiar patterns depending on whether the plant or animal lives in air or water,' he writes in the introduction, adding, in a line that has become my mantra: 'In part, [this book] is an exercise in examining how a terrestrial existence has biased our perception of biology.'

For example, he points out that sea water is twenty billion times more conductive of electricity than air. It's difficult from our terrestrial perspective, as he mentions, to understand what it would feel like to be able to communicate so easily through electrical impulse. The very movement of a muscle sends out electricity that can be discerned in the ocean. What hit me like a lightning bolt in all of this was the simple concept that chemistry and physics determine biology. Therefore as chemistry and physics change, so will biology. And what I've been finding through my research for this book is that the chemistry and physics of the global ocean *are* changing.

What are the implications? What will happen to the oxygen in the ocean, the plankton that power both the biogeochemical cycle and the ocean food web? Will the ocean still support fish? Will the splendid creatures that live there now still be able to mate and produce viable young? Can humanity survive the chaos to come? And, finally, can we rein in ocean change before it's too late?

It depends on how much the chemistry and physics change. The evidence right now is that they have not changed this dramatically in about fifty-five million years, since the Palaeocene epoch lurched into the Eocene, a time of great biological upheaval. We are not talking about atmosphere or air—that secondary and important medium of life on earth—but of ocean, the primary medium. We are at a rare and frightening point in the history of life on the planet.

I came to think of this phenomenon in medical terms, because

those are easier for me to understand. Like many parents I have sat through the night with a feverish, delirious baby, trying to keep the body temperature down with drugs, cool cloths, calm hands to the forehead. It's a scary place to be, especially if the child's temperature keeps rising. The danger is that if the temperature rises too high, the baby's system can't handle it and brain damage—or even death—follows. That catastrophe is relatively rare in the modern Western world, where medicine is at hand. Like many parents, I have rushed a feverish child to the emergency room for lung X-rays, the anxious needle tap of the spinal column, bags of intravenous fluid, intravenous antibiotics. And averted disaster.

What makes fever so dangerous is that the body as a whole thrives only within certain chemical and physical boundaries: its systems are set up to keep the body within those boundaries. A temperature of 40 degrees Celsius is a hand-wringer. At 41 degrees, you're at the hospital. The human body can't work very far beyond that number. Instead it hits its limit and then switches to a system that is geared toward death instead of life. The human system has chemical and physical ranges that run the gamut from optimum to impossible.

I remember a searing chemistry lesson from the day my first child was born. Throughout her gestation she had bled copiously, silently, into me through our placenta. By the time she was supposed to be born, she had little blood left in her own system, and had filled her veins and arteries with fluid to survive. Finally, still in the womb, she just stopped moving—except for her swollen heart, which kept a perilously even rhythm.

When she was born by emergency Caesarean section, her haemoglobin count was 26. It should have been 155. She was in cardiac failure, limp, chalk white, soundless. The chemistry was wrong. Through the long afternoon and evening while doctors worked to save her life, one equation kept running through my brain: *Haemoglobin, red blood cells, oxygen. Haemoglobin, red blood cells, oxygen.*

How could this child survive if she had had so little oxygen?

They transfused her. She was a hell of a fighter. She survived to become a remarkable young woman. The doctors could never explain to me how her infant body had leapt over the chemical assault, only that, somehow, grace had struck.

So when I think of the planet, I think of it as a body with some serious health problems. The evidence is that the chemical levels of its ocean-blood are changing and that is affecting such things as pH, metabolism, fecundity and ability to thrive. In a growing number of places, the very oxygen content of the ocean is trailing off. These are its vital signs, and they are telling us that the planet is in distress. The planet is slipping into biological and evolutionary unconsciousness. A point of no return. A switch.

As the eminent marine biologist Jeremy Jackson of Scripps Institution of Oceanography, University of California at San Diego, wrote recently, we are creating a 'brave new ocean' that, without profound and multi-faceted changes in human behaviour, will lay the groundwork for a 'mass extinction in the oceans with unknown ecological and evolutionary consequences.'

This doesn't mean that life will stop. It means that *life as we know it* will stop unless we can return the planet to health. But if we cannot, the components that provide the possibility for life in the future will still be here, sleeping and poised to spring back once a new system conducive to life emerges.

The medical imagery helps me understand in other ways, too. Our modern society spends billions upon billions of dollars to diagnose illness early in humans, and to treat it before it becomes acute. Think of the money for routine diagnostic breast X-rays of middle-aged women to catch breast cancer before it progresses too far—staff, hospitals, doctors to read the scans and interpret them, the machines.

Or the millions of humans on cholesterol-lowering drugs and medicine to lower blood pressure, a bid to keep their hearts from

failing. Think of the industries, the science and research, the development, manufacturing and distribution know-how, the training of doctors and pharmacists that has gone into making sure that those drugs get to the humans who are supposed to benefit from them.

So I'm left with questions. If we have created modern medical systems capable of trying to prevent human illness, at the cost of many billions of dollars a year, why are we not looking at preventing—much less diagnosing and treating—the illness of the planet-body that gives us life?

The medical metaphor became particularly poignant for me as I watched scientists even in the richest countries struggle to cobble together money to conduct the research necessary to understand the planet's basic functions. The sum of a few hundred thousand dollars here or there makes a huge difference to most of these scientists and they must forsake research that funding agencies don't think is important enough. Yet these scientists are our planet's doctors and diagnosticians, the few able to read the vital signs of our life-support system and maybe, just maybe, figure out how to fix it.

Sitting in a conference centre in the Basque stronghold of Bilbao, Spain, for the research for this book, I became convinced that never in the history of human life has the work of scientists been so important to the fate of our species.

That was my lowest moment. I felt like a doomed character on an ancient quest, destined to explore the fundamental crisis of the human condition, driven to search for redemption but fated to fail.

It was another prophet who helped me climb out of that. Matthew Fox, the excommunicated Catholic priest and seer from California, showed up in my living room in frozen Toronto one Sunday morning, explaining that humans need to feel despair before they can find hope.

In Christian language, one needs the pain of loss to understand the surprising gift of resurrection. In the language of classical literature, one must lose Troy before it is possible to build Rome, or grieve over the deaths of Romeo and Juliet before reconciliation can be born. In biological terms, winter's death must come before spring's birth.

So is there hope?

You could focus on the fact that the number of scientists now involved in examining the health of the planet is growing dramatically. New findings are being announced every day. The picture is becoming clearer. The science is gelling.

You could look at the fact that, since Flannery and Gore and Stern and Katrina, it's plain that most of humanity in developed countries gets at least part of the big picture of carbon and that's different from even a couple of years ago. The dialectic has shifted, at last.

For me, it took a journey to the deeps—almost a kilometre to the bottom of the ocean—to see whether or not I could find hope. It was a scientific expedition with Harbor Branch Oceanographic Institution, a private group based in Florida, set up decades ago with a whack of money from one of the founders of Johnson & Johnson, the baby powder and pharmaceuticals company.

Just to put it in perspective, a kilometre is incredibly deep. There are parts of the ocean floor that go much deeper—to about 11 kilometres—but hardly any humans have ever voyaged to a kilometre and, as far as the Harbor Branch group knew, not a single journalist before me. The pressure at that depth is intense and would be instantly fatal if the craft sprang the smallest leak.

I was terrified. But I had spent two years obsessed with the ocean, this grand mother of life, and I simply had to be inside her, to see her for myself. I needed to bear witness to as much as I could see of this vast third dimension of the ocean that has such biological power over our planet. So I hoisted myself into

the tiny aluminium chamber that was to carry me and the ship's electronics engineer down to the ocean floor. The hatch clanged shut and we lay side by side to fit.

It is pitch black at the depth of a kilometre and it is bitterly cold. I was intently focused on the composition of the air in my aluminium womb. It became a microcosm for the chemical changes to the atmosphere and ocean that this whole book is about, to the idea that a system has limits.

I had an epiphany there. It had to do with the nature of hope. And I rolled out of my watery cradle three hours later tremulous, moved, triumphant, convinced that our species, with all its failings and trudgings, is ready for its toughest journey yet.