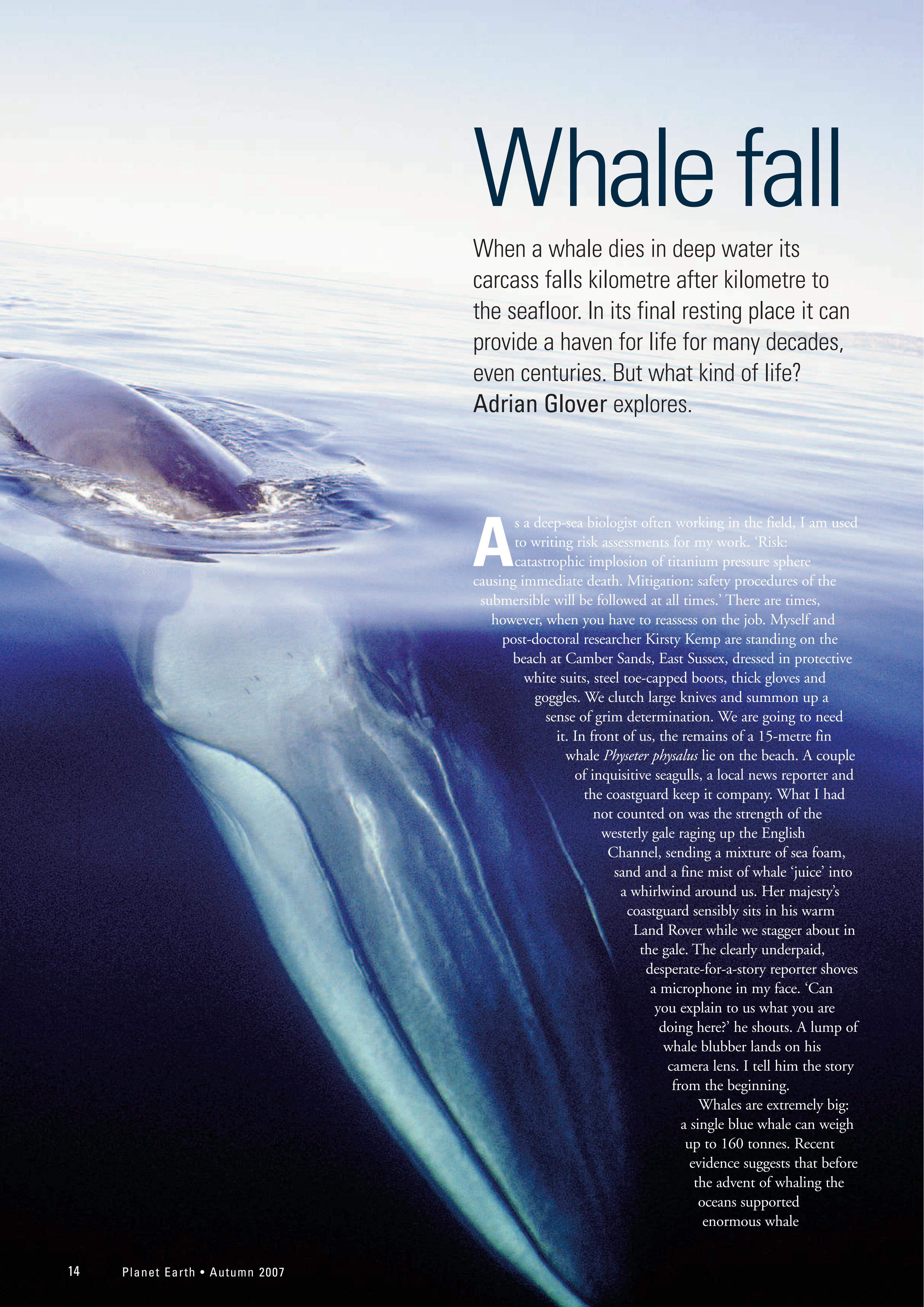

Whale fall

When a whale dies in deep water its carcass falls kilometre after kilometre to the seafloor. In its final resting place it can provide a haven for life for many decades, even centuries. But what kind of life? **Adrian Glover** explores.

As a deep-sea biologist often working in the field, I am used to writing risk assessments for my work. 'Risk: catastrophic implosion of titanium pressure sphere causing immediate death. Mitigation: safety procedures of the submersible will be followed at all times.' There are times, however, when you have to reassess on the job. Myself and post-doctoral researcher Kirsty Kemp are standing on the beach at Camber Sands, East Sussex, dressed in protective white suits, steel toe-capped boots, thick gloves and goggles. We clutch large knives and summon up a sense of grim determination. We are going to need it. In front of us, the remains of a 15-metre fin whale *Physeter physalus* lie on the beach. A couple of inquisitive seagulls, a local news reporter and the coastguard keep it company. What I had not counted on was the strength of the westerly gale raging up the English Channel, sending a mixture of sea foam, sand and a fine mist of whale 'juice' into a whirlwind around us. Her majesty's coastguard sensibly sits in his warm Land Rover while we stagger about in the gale. The clearly underpaid, desperate-for-a-story reporter shoves a microphone in my face. 'Can you explain to us what you are doing here?' he shouts. A lump of whale blubber lands on his camera lens. I tell him the story from the beginning.

Whales are extremely big: a single blue whale can weigh up to 160 tonnes. Recent evidence suggests that before the advent of whaling the oceans supported enormous whale

Mark Jones/OSF

populations with up to 350,000 fin whales in the north Atlantic alone, compared with the estimated 56,000 today. We think the success of these baleen whales is down to their efficient feeding mechanism – eating small krill near the bottom of the marine food chain.

But what happens to these enormous organisms when they die? Whilst some, like the fin whale in front of us, may strand on shorelines, we think the majority fall to the ocean floor providing food for scavengers. Researchers have long speculated on the fate of such large 'islands' of organic matter on an otherwise food-poor seabed. The first report of a specialist organism associated with dead whales came from a paper in 1900 describing a tiny mussel, *Adipicola simpsoni*, collected from a whalebone trawled up by a fisherman off the coast of Aberdeen in Scotland. Isolated reports of molluscs and trawled whalebones continued through the twentieth century. But it was not until quite recently that a chance discovery provided the first real evidence as to the fate of whales in the deep sea.

In November 1987, Craig Smith, an oceanographer at the University of Hawaii, was using the deep-sea submersible *Alvin* off the San Diego coast at a depth of about two kilometres. On one dive the sub crew returned having found what they said looked like a dinosaur skeleton on the seabed. No dinosaur, the huge skeleton was in fact the remains of a blue or fin whale, and the first direct observations of what the scientists now call a 'whale-fall'. Quickly realising the significance of the find, Craig used the hi-tech features of the submersible to carefully collect bones, associated animals and sediments from around the remains. What they found astonished them. Giant clams, previously found only at hydrothermal vents – the deep-water volcanic chimneys rich in life – had colonised the bones. The clams, rather than feeding using a mouth and gut, obtain their nutrition by hosting special bacteria inside their gills that can obtain energy from the sulphur-rich fluids emitted from the vent chimneys, or in this case the decomposition of the thick, oily whalebones. An intriguing hypothesis presented itself – could these whalebones scattered across the ocean floor provide 'stepping-stones' for the dispersal of species that live around vents?

A publication in the scientific journal *Nature*, and the fascinating field of 'whale-fall biology' was created. Since that time, scientists have been studying whale-falls by sinking the remains of dead, stranded specimens and studying them over time using remotely operated vehicles (ROVs) or submersibles. A

Osedax mucofloris,
the bone-eating snot-flower worm.

> Nothing like it had ever been seen before.

picture has emerged of large whales going through a series of decompositional stages with the initial removal of the flesh by scavengers, such as hagfish and sleeper sharks, lasting several months. This is followed by colonisation from specialist whale-fall or vent-related organisms, many new to science. One of the most spectacular finds took place in 2002 with the discovery of the remarkable 'bone-eating' worm *Osedax* on a whale carcass three kilometres down in the Monterey Canyon off the coast of California. This red-plumed, flower-like worm burrows roots into the bones and uses specialist bacteria to directly feed off the whale oils. Nothing like it had ever been seen before and it was only the DNA sequence of the animal that finally confirmed it as a segmented annelid worm, related to species found at 'black-smoker' deep-sea vents.

Despite these advances, we are still left with many unanswered questions. How do these relatively tiny organisms disperse between isolated carcasses across the vast plains of the deep ocean? Do species living around hydrothermal vents really use whale-bones as a dispersal route, or are they more distantly related? Did *Osedax* evolve when whales first evolved around 50 million years ago, or could they have used the skeletons of other large marine reptiles from the time of the dinosaurs? How does a worm like *Osedax*, without any mouth or gut, obtain nutrition from the whalebone?

Back on Camber Sands, I remind myself of these questions as Kirsty and I wrestle to dissect some vertebrae from the least-disgusting looking end of the whale. We are working on a project that is looking at whale-falls in the north Atlantic. Our plan is not to sink the entire whale – something of a logistical challenge for this one – but to sink a package of whalebones for continued studies using ROVs. With my collaborator Thomas Dahlgren at Göteborg University, Sweden, we have already found a new species of *Osedax* from the relatively shallow waters of a Swedish fjord. Thanks to a NERC New Investigator grant, I have been able to study two whale carcasses in the North Sea, and we have already placed two further bone-packages off the west coast of Scotland. One of our goals is to address one of the central questions in deep-sea biology: how do organisms associated with isolated 'island' habitats such as vents disperse between them? We are doing this by combining our studies of reproduction with a broad-scale study of the evolutionary history and population genetic history held within *Osedax* DNA sequences. Our data will also help us to understand the true impacts of twentieth century whaling on marine ecosystems.

Covered in stinking whale blubber, blood and sand, we stagger back to our car, desperately in need of a shower and change of clothes. I mentally note to include a new risk on my next form – 'risk of being refused lunch in a local pub owing to smell of scientists in team'. ❖

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