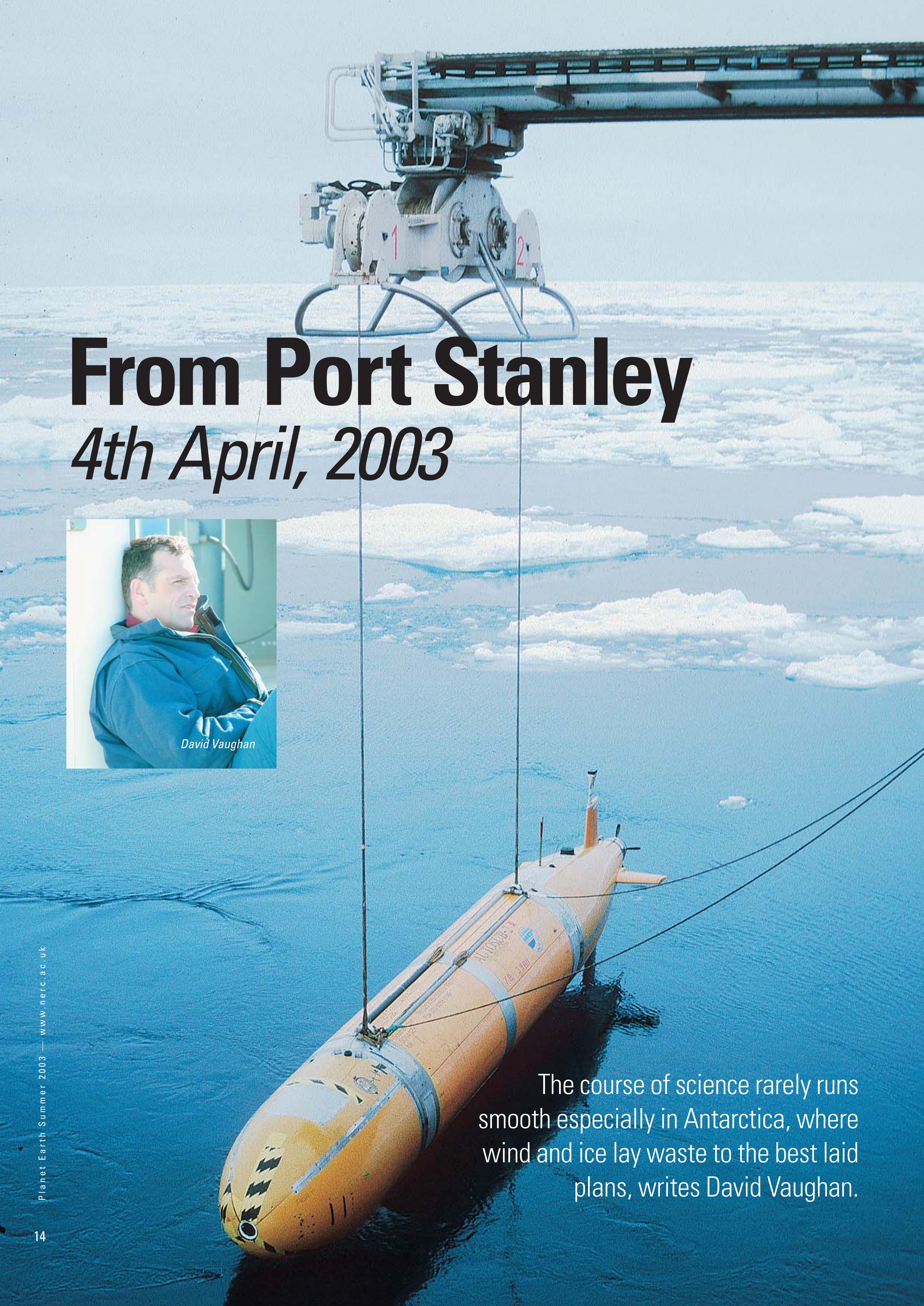
From Port Stanley
4th April, 2003



David Vaughan

The course of science rarely runs smooth especially in Antarctica, where wind and ice lay waste to the best laid plans, writes David Vaughan.

Without bands or adoring crowds on the quayside, the research vessel *James Clark Ross*, bearing the scars of recent ice, slides alongside the quay at Port Stanley in the Falkland Islands. This quiet return suits my mood.

We, the 50 returning crew and scientists, have spent the previous six weeks in the Southern Ocean and seas near Antarctica collecting some scientifically important datasets. We made maps of the seabed recording the state of the immense Antarctica ice sheet at the last glacial maximum (around 21,000 years ago) and our oceanographic measurements will show how warm water creeping onto the continental shelf may rapidly melt the ice sheet. But we narrowly missed the opportunity of a career – the chance to bring a new and unique piece of technology to bear on some truly important scientific questions. But science is never easy, and ice and wind conspired to block our path to an extraordinary and elusive corner of Antarctica.

Our story began more than ten years ago. Then manned or remotely-controlled submersibles were already routinely investigating oilrigs and pipelines and even black smokers, but these vehicles could do little more than dive to the sea bed, wander around a tiny area and then come straight back to the surface. Then, in July 1996, Southampton Oceanography Centre announced that it had built an autonomous submarine vehicle called Autosub. Autosub could dive, follow any preset route, swim up and down through the water column, and return to its mother ship unaided, all the time logging temperature, salinity, and currents. Even more impressive, Autosub had onboard intelligence and could swim at a constant height above the sea floor, or identify an obstacle in its path and work out how to avoid it.

Autosub caused an immediate stir, with many oceanographers imagining how they could use it. The prize was to use Autosub to do something new, something that couldn't be done in any other way.

Around the same time, Keith Nicholls's team from the British Antarctic Survey designed a simple but rather elegant system to pump hot-water from melted snow out of a lance on the end of a very, very long pipe. The jet cut through glacial ice like butter, and they used their hot-water drill to make access holes through the largest ice shelf in Antarctica. Filchner-Ronne ice shelf has an area (if not cultural richness) similar to France, and although it's up to 1,500 metres thick, it floats on a sea-filled cavity – a vast unexplored sub-glacial sea.

Nicholls' team drilled holes just wide enough to drop narrow oceanographic sensors into the sea below. Their instruments gave us a tantalising glimpse of a sea comprising two layers, a briny one flowing inland near the seabed, and a fresh colder layer near the ice flowing back towards the open ocean. Clearly, the ice shelf was melting, and the process of melting was ejecting cold fresh water into the Southern Ocean. The conditions pointed to a mission that Autosub, and Autosub alone, could complete. Keith, Gwyn Griffiths from the Autosub team and Julian Dowdeswell, now Director of the Scott Research Institute at Cambridge University, took a proposal to NERC, and their idea became a thematic programme: Autosub Under Ice (www.nerc.ac.uk/funding/thematics/autosub/). NERC funded many proposals, including my own which focused on another ice shelf in Antarctica: Pine Island Glacier.

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For the most part the first division ice streams draining the Antarctic ice sheet produce enough icebergs and melt to match the amount of snow falling on their interior. Pine Island Glacier is the one exception. Recent satellites have given different views of Pine Island Glacier, and every view seems to show that it is changing. Its interior is thinning, the point at which it begins to float is retreating inland, and its main trunk is also thinning at more than three metres per year. This imbalance is important to understand. If all the water frozen in this one glacier basin melted it could raise global sea level by about 50cm and some glaciologists believe the ice sheet in this area is unstable. But although we can map the changes, observations over a ten year period are no basis for long-term prediction. We need to understand the root cause of the change.

Thus Pine Island Glacier became the target for the first Autosub Under Ice cruise, but with such a difficult focus, considerable contingency was built into the cruise. Adrian Jenkins, the cruise leader, led a project that focused on getting to the glacier, putting Autosub beneath it and getting data back from the sub-ice shelf environment. Adrian would use oceanographic measurements to investigate whether warming ocean water is causing the changes in the glacier. I would map the features and structure on the ice and seabed to assess the likelihood of periodic surges, increases in glacier flow-speed driven only by internal instability in the ice itself. Mark Brandon's team from the Open University would investigate

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sea ice production, and Julian Dowdeswell's team would use the ship's multi-beam echo sounder to map the seabed. Autosub's handlers from Southampton Oceanography Centre, led by the ever-ebullient Nick Millard and his taciturn software engineer, Steve McPhail, would deploy and retrieve Autosub, and manage all its complex systems.

We left Port Stanley at the end of February and sailed across Drake Passage to Antarctica with Autosub silent in a makeshift kennel on the aft deck. We launched Autosub on test missions in sheltered waters off the Antarctic Peninsula, while humpback whales took only a lazy interest. We steamed south, past the desolate Peter the First Island, a relict volcano rising 3,000 metres from the depths of the Southern Ocean and on into Pine Island Bay. But just as we were in striking distance of Pine Island Glacier, a cold southerly wind blew off the continental ice sheet, and the ship's bridge received satellite images indicating that ice was forming near the glacier. We woke to find the ship in new ice, just as visible as streaks of grease on the surface of the sea. As we steamed on the grease, ice thickened into pancake ice, which in turn became sheets of nilas. The prognosis got worse. Once sea ice begins to form it tends to shield the surface from the mixing action of the wind. Without mixing there is no heat to melt the ice. Once ice had begun to form, we needed a strong wind to break it up and stir the surface waters. A strong wind might have given us a few more weeks of open water near the glacier.

> *Ice and wind conspired to block our path to an elusive corner of Antarctica.*

We continued steaming south through a narrow passage between a plume of icebergs and a barrage of old floes. We were becoming increasingly concerned that if this passage closed up we'd be beset. With the Antarctic winter only a couple of months away this was less than appealing. No wind came to break up the ice. Under the greyest sky, the ship's bows carved a huge semi-circle through the whitening sea and we headed out the way we'd just come in.

Safely beyond the ice edge, Autosub proving tests continued, but these too were dogged by difficulties. Electrical connectors, designed to cope with the extreme pressure, intermittently failed in these deep sub-zero waters. And just as we solved those problems, Autosub took an unexpected nosedive at the stern of the ship and required 48 hours of intensive care in the kennel.

Finally, just as the door to Pine Island Glacier had closed silently in our face, new satellite images showed sea ice forming around every other ice shelf within our range. Even a proving test under another ice shelf was out of the question. Suddenly, we were very pleased to have other projects to attend to. Adrian worked with Mark's team and located a seabed trough where unusually warm water slides up the continental shelf towards the ice sheet. Julian Dowdeswell's team produced astonishing maps of the seabed showing features left as glaciers ploughed their way to the edge of the continental shelf 18,000 years ago. Those marks hint at an immense ice stream, one that could have dwarfed today's Pine Island Glacier. We launched Autosub beneath sea ice and observed dense brine, the by-product of sea-ice production, sinking through the surface waters, a process known to be a major driver of ocean circulation.

These projects achieved valuable and important results in their own right, but as one philosopher in the officer's lounge noted, 'We didn't get to Pine Island Glacier and so we don't get a cigar'. This morning we arrived back in Port Stanley, and I hope the officers, crew, scientists, and Autosub handlers are content in the knowledge of a job well done. The important oceanographic and geophysical discoveries of the cruise stand as evidence of their efforts. But for Adrian and I there's a sense of lost opportunity, from having been so close, but ultimately thwarted by forces beyond our control. That feeling will continue until we can convince the purse-holders that we can overcome the problems that beset us this time, that understanding the change in Pine Island Glacier is still a research priority with scientific and social significance, and that a second attempt must be funded. Only when we have got another ship, Autosub in its kennel, and are cracking on through the ice towards Pine Island Glacier, will we lay this ghost to rest.