

Deckchair science

There are worse places to do research, but for the Caribbean cruise ship *Explorer of the Seas*, home to two climate laboratories, it's not all smooth sailing. Emma Marris finds out why.

Oceanographer Rik Wanninkhof was stranded. Working at the Atlantic Oceanographic and Meteorological Laboratory in Miami, Florida, he had developed an instrument to measure carbon dioxide levels in the ocean. After a number of dry runs, he was eager to test it at sea, and so he placed several of his sensors on the only research vessel available. But the ship was scheduled to sail to South America and Europe, so if anything went wrong, he would have to fly a long way at considerable expense to fix the problem.

Salvation came from an unexpected quarter: Royal Caribbean Cruises. The holiday company offered him the chance to install his sensors on *Explorer of the Seas*, a 3,000-passenger luxury cruise ship, which is also home to two sophisticated laboratories, one each for atmosphere and ocean research. So Wanninkhof's instruments went on an extended tour of the Caribbean.

The cruising labs are a joint project between Royal Caribbean and the Rosenstiel School of Marine and Atmospheric Science at the University of Miami. As research vessels are both expensive and scarce, oceanographers have been jumping at the chance to place instruments on board *Explorer of the Seas* for free. They may also be attracted by the stability of a large ship, as opposed to the pitch and heave of a tiny, crowded research vessel, where even the saltiest of scientists go green about the gills. Whatever the reason, they have been signing up in their droves.

But it's not all plain sailing. A cruise ship that only stops in port and never leaves the Caribbean is not suitable for every project. And a notable lack of publications based on data from the ship has some researchers questioning the usefulness of the arrangement. This dearth of results combined with the declining fortunes of the cruising industry



Lap of luxury: the cruise liner *Explorer of the Seas* doubles as a floating lab for climate research.

has left the project with an uncertain future.

The idea of cruise ship labs originated as part of Royal Caribbean's effort to clean up its image following a series of pollution scandals in the 1990s. After admitting that its ships had been illegally discharging oil and waste chemicals into the sea for years, the company promised to stop and agreed to pay millions of dollars in fines. In 1996, it established the Ocean Fund, which makes grants to conservation organizations.

To run it, the firm turned to Otis Brown, dean of the Rosenstiel School. One day, Brown happened to complain in front of Royal Caribbean's president, Jack Williams, about the cost of research vessels. What emerged was a realization that cruise ship labs could benefit both the cruise line and oceanography.

Sea view

For researchers, the rewards were obvious. Cruise ships sail the same course over and over, so long-term data sets can be assembled about certain locations. And they are massive — more like reclining skyscrapers than boats — so their inherent stability means that the instruments don't sway or get knocked about. Perhaps most importantly, researchers get more of a scarce resource: sea time.

Royal Caribbean was expected to benefit too. Brown and Williams imagined that hosting a lab investigating such things as climate change and the transportation of invasive species in bilge water would help the company's environmental image. The lab was also expected to be an attraction for passengers, on a par with the ice-skating rink and climbing wall.

Additionally, as part of the deal, Brown agreed to find one researcher each week to go on board for the benefit of the cruisers. Each

visiting scientist would give two lectures, a general talk called 'Dive into marine science' and a non-technical explanation of their own area of expertise. They would also give tours of the labs and act as an informal ambassador of science in their free time, if only by chatting with passengers over drinks.

For its part, Royal Caribbean came up with US\$3 million to add the two laboratories to *Explorer of the Seas* as it was being built in Finland for launch in 2000. To fit the labs with the latest equipment, Brown convinced several initially sceptical federal research agencies, including the National Oceanographic and Atmospheric Administration (NOAA), to chip in a few million more.

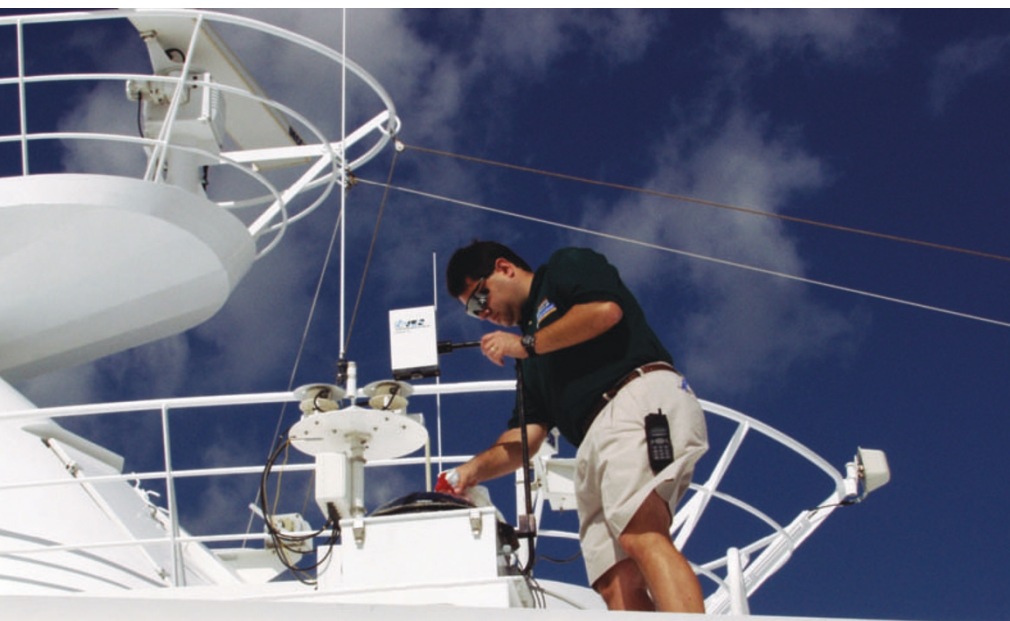
It wasn't hard to find researchers willing to take advantage. Strapping instruments to boats other than dedicated research vessels has long been a tactic of climate scientists, one that has allowed them to get information from around the world, often from ships that ply repeated tracks. But the instruments on such ships are often unmanned and cheap, even disposable.

Star attraction

In contrast, the labs on *Explorer of the Seas* are attended continually by two onboard technicians. The instruments, which are either bolted to the hull or tucked away on a mast, are top of the range. They include two acoustic Doppler current profilers to image the currents and marine life at various depths, an emitted radiance interferometer to measure the temperature of the sea's surface with extreme accuracy, and a radian wind profiler, which tracks wind speed at various elevations overhead. One machine does nothing but take pictures of clouds.

The labs themselves, conceived by Royal

D. B. ENFIELD/NOAA/AOML/PHOTO



Cruise control: from the labs on the liner, researchers guide a range of instruments and experiments.

Caribbean designers, look as if they have come straight off a Hollywood set. They combine flat-screen monitors, hidden wires, blue neon lights and burnished chrome in an aesthetic statement Brown describes as somewhere between Jules Verne and *Star Trek*.

The boat has two routes, alternating weekly. One track goes from Miami to San Juan, Puerto Rico, and the other makes a loop around Cuba, stopping at Jamaica and Cozumel off the coast of Mexico. As the ship ploughs through the same waters, the instruments collect and transmit the data back to the Rosenstiel School via satellite.

This sort of repetitive sampling is particularly well suited to climate research, the main thrust of most of the work on *Explorer of the Seas*. The researchers — from the University of Miami, NOAA and an increasing number of other institutions — have set out to collect data on as many atmospheric and oceanic variables as possible to learn how the air, water, wind, sun and sea life interact, as well as how the whole system changes throughout

the year. Ultimately, the data generated should help them to understand how long-term climate trends such as El Niño and global warming are affecting the region.

Choppy waters

But it's a slow business, and very few papers have come out of the research so far. This has led some researchers to wonder whether the flashy labs will produce interesting science. "They have been slow to work it into a scientifically usable shape," says Tom Rossby, an oceanographer at the University of Rhode Island in Kingston, who puts his equipment on freighters, although he concedes that such long-term studies could take more time to come to fruition.

One reason for the delay may be that the ship is always in motion, making it impossible to lower deep-water sampling devices, says John Orcutt, deputy director for research at the Scripps Institution of Oceanography in La Jolla, California. As a result, the water samples all come from the top layer of the sea, a

comparatively hurly-burly place where long-term trends are harder to pick out. "To get at climate change, you sample deep," he says. "Their signals for things such as long-term change are going to be very noisy." He expects that, because of this, real results will take longer to emerge from the background din.

Lack of publication is rarely considered a positive sign by grant makers, and Brown spends a good deal of time cobbling together funding from a variety of agencies and private donors. After grants from NOAA and the National Science Foundation expired, for instance, Brown succeeded in winning new support from the Office of Naval Research and the University of Miami.

Turning tide

Compounding the money problem, the cruise line itself has withdrawn some of its support. Although it still provides the free berth and lab space for researchers, it no longer helps to maintain the instruments or cover the salaries of the onboard technicians. Brown says that the change was abrupt, following the drop in tourism after the terrorist attacks on 11 September 2001: "They said: 'We're going to try to keep the ship running. Your problems are your problems'."

Of course it's not new for long-term studies of the type done on the ship to face funding challenges, Brown points out. "The ocean-science support system has not really been sensitive to the needs of long-term projects," he complains. Dean Roemmich, a professor at Scripps, says that funding such studies is a constant challenge. "It takes a lot of patience to see results," he says. "It's hard for people to understand. There is this period where we are trying very hard to prove our value."

On the bright side, the results that might prove the project's worth are finally emerging. In February, Wanninkhof's tests led to one of the first published findings from *Explorer of the Seas*. His instruments picked up a significant seasonal variation in carbon dioxide levels that correlated with temperature changes, despite expectations that CO₂ levels were fairly constant in the region. This finding might make it possible to estimate CO₂ levels by taking the temperature of the sea surface from a satellite (A. Olsen, J. A. Triñanes and R. Wanninkhof *Remote Sens. Environ.* **89**, 309–325; 2004).

Despite all the uncertainties, researchers are queuing up to board *Explorer of the Seas* — the waiting list is eight months long. It's quite a change for those used to rougher outings. When not lecturing or installing instruments, they can swim, sunbathe or go ice-skating. But it's no junket. They can only drink outside working hours, and are not allowed to gamble. "This is not a 'lie by the pool and get a drink whenever you are thirsty' kind of thing," Brown says. "You actually do work."

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