Rooting for radium

Willard Moore and his colleagues collected 200-litre samples of sea water from depths of up to 1,000 metres and stirred up the odd octopus in order to determine the input of submarine groundwater discharge into the Atlantic Ocean.

W.S. MOORE

Seepage of submarine groundwater discharge onto an Atlantic Ocean beach in southeastern Brazil. The red stain is due to oxidation of soluble iron after exposure to the atmosphere.

What was the objective of the work at the beginning of the project? Did it change as work progressed?
We gathered the ocean data as part of the project "Transient Tracers in the Ocean" during the early to mid 1980s. The objective of this project was to use chemical tracers, such as tritium, carbon-14, and freons in combination with general ocean circulation models to determine the circulation and mixing rate of the Atlantic Ocean. But the data on ^{228}Ra — collected because of its short half life of 5.7 years— have been dormant since 1990.

In 1995 I discovered that an important source of radium to the ocean was submarine groundwater discharge (SGD). Existing techniques can evaluate SGD on a scale from 1 m^2 using a seepage meter, to a few hundred km^2 from regional surveys based on measurements of radium isotopes and radon gas, a decay product of ^{226}Ra.

The large Atlantic Ocean inventory of ^{228}Ra told us, on the scale of an ocean basin, how much ^{228}Ra needed to be supplied each year to replace the loss from radioactive decay. Therefore, if we could quantify non-SGD sources of ^{228}Ra to the ocean, we could use our database of the concentrations of ^{228}Ra in SGD to determine the total SGD flux to the Atlantic Ocean.

What sorts of data or samples were used in this study?
To measure ^{228}Ra in the open ocean we required very large samples of seawater, of at least 200 litres each. These were collected from depths of up to 1,000 m in large steel samplers and returned to the ship, where radium was extracted from the water and measured later in the laboratory. To determine the ^{228}Ra concentrations in SGD we required only a few litres of water from springs, monitoring wells or temporary samplers. We installed nine monitoring wells about 15 km offshore North and South Carolina at 12 to 16 m water depths. These are instrumented with temperature recorders and sampled by divers annually, or as funding permits. We also extracted water from permeable sediments on beaches and in salt marshes using temporary samplers.

Were there any encounters with dangerous animals?
Not dangerous, but certainly startling. During a dive to an SGD monitoring well off the coast of North Carolina, a diver discovered that the cap on the well had become dislodged, probably during a hurricane. He reached into the well trying to find the string of temperature recorders, when something grabbed his hand. As he jerked it back he realized that he had disturbed an octopus who had taken up residence in the open well.

What was the highlight of this project?
For me the highlight was scaling down the results for the entire Atlantic margin to those from two regional studies. I found the SGD per km of shoreline to be very similar, meaning that the different methods agreed; this gave confidence in the new method.

Did this project give you any ideas for future research projects?
Yes it did. We now have a good estimate of the total SGD input, but what we ultimately would like to know more about is the supply of nutrients, metals and carbon through SGD, and its impact on coastal ecosystems and the ocean budgets of these materials. For that, we need more information on the concentrations of nutrients, metals and carbon in SGD in order to be able to estimate their fluxes to the ocean via SGD. This will probably change the ocean budgets for many materials. Additionally, the inventory of ^{228}Ra in the upper ocean integrates all processes on the margins that supply ^{228}Ra, such as rivers, diffusion from fine-grained sediments, and SGD. By monitoring the oceanic ^{228}Ra inventory, we will learn if the processes that supply ^{228}Ra are changing.

This is the Backstory to the work by Willard Moore and colleagues, published on page 309 of this issue.