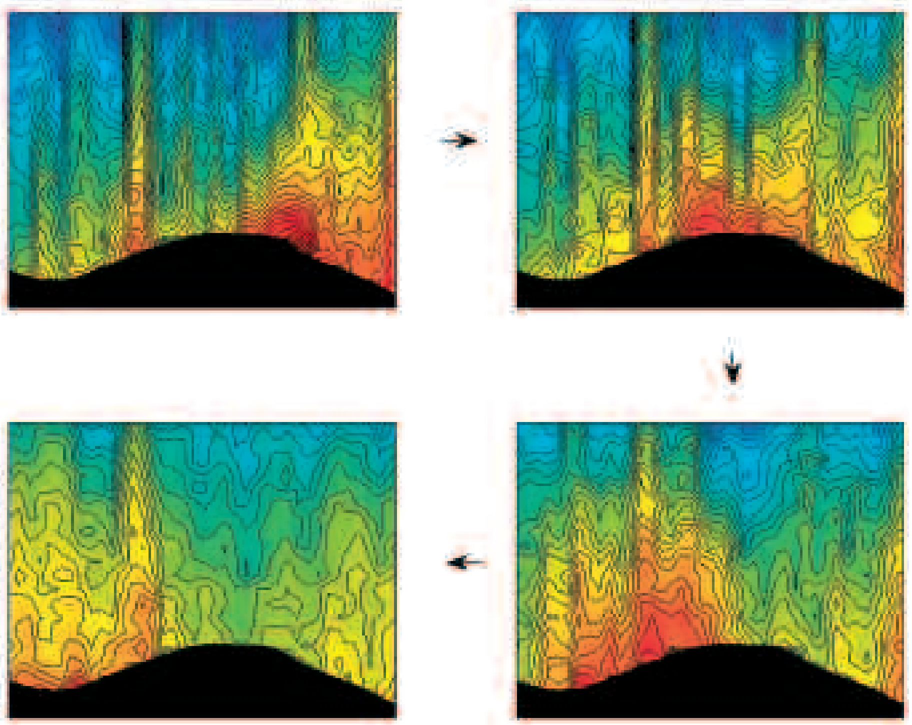
Sounding out our coastlines and

Forecasting evolving coastlines is tricky. Peter Thorne explains how sound and sand can help.



Images from the Deltaflume show how a cloud of sediment moves as a wave passes over a ripple (red is highly concentrated sediment, blue is low).

English Nature, the government's environment watchdog, estimates that at least 130 million square metres of English shoreline—much of it vital wildlife habitat—will disappear in the next 20 years.

As climate changes, higher sea levels or more frequent storms may change the way sediments, sands and muds, move around our coasts, continually modifying shorelines and estuaries. You only have to look at Holderness, Norfolk, and sections of the south-west coast of England to see what's already happened, and the effects on local populations.

Such changes are becoming surprisingly common, partly because predicting and managing sediment transport is far from simple. I remember when dilapidated groins on Sidmouth beach, in south Devon, were replaced with a nearshore breakwater to provide protection. The beach was completely washed away, needing a renourishment programme to build up what had previously been a relatively stable beach. Scientists have been researching how sediments move for over 50 years, but we still don't have accurate forecasts of coastal change.

When you paddle in the sea, you can often see and feel rippled sand underfoot, with more sand wafting around as the waves move. This apparently simple process is more complicated than it might appear. The complex water flow over the ripples lifts sediment into the water, reshaping the ripples, which in turn changes the flow. To predict what will actually happen to the coast, we need to represent this movement mathematically, then factor in the complicated effects of tides and changing waves.

Researchers Jon Williams and Paul Bell of Proudman Oceanographic Laboratory (POL) recently co-ordinated a six-week pan-European experiment into such interactions at one of the world's largest wave channels, the Deltaflume of Delft Hydraulics, at the De Voorst Laboratory in Holland. This man-made channel is 230m long, five metres wide and seven deep, and is used to study sediment transport under full-scale wave conditions.

The team used sound to penetrate through the muddy and sandy waters and build up images of the bed and the sediments above it, akin to the way ultrasound is used in medicine. John Humphery developed the main instrumentation at POL. STABLE II (Sediment Transport And Boundary Layer Equipment) is a package of autonomous instruments that can stand on the seabed for weeks, measuring interactions between the flow, the bed and transported sediments in detail.

We're now working with Alan Davies, in the School of Ocean Sciences at the University of Wales, Bangor, using our findings to assess his mathematical model of sediment transport. This sort of sophisticated mathematical model holds the best hope for improving forecasts for evolving coastlines—and hopefully protecting dear old Blighty into the future.

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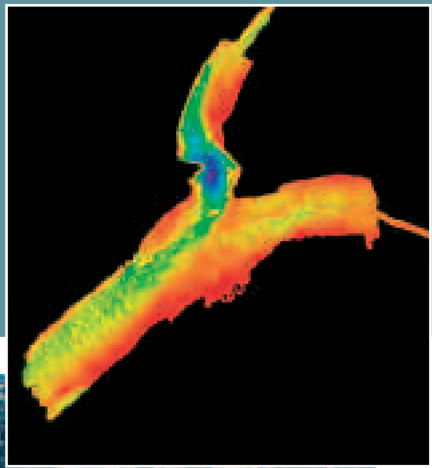
rivers



Map of the bed at the Rio Paraná-Paraguay junction. The dark blue is the 35m deep scour hole.

Size matters when it comes to understanding river junctions, say Dan Parsons and Jim Best.

The Rio Paraná (left) and Rio Paraguay (right) collide. The Rio Paraguay is about 350m wide at the junction. The contrasting colours show mixing here is often very limited.

Where the Rio Paraná and Rio Paraguay collide, on the Argentina-Paraguay border, 16 million kilograms of water crash together every second. All river networks have such junctions (or confluences), but this is one of the world's biggest.

Confluences are the building blocks of river networks, affecting water flow and speed, flooding levels, bank erosion, pollutant dispersal and sediment movement both up- and downstream.

Most of what we know about colliding rivers is based on laboratory models and field studies in small streams, usually within channels less than about 10 metres wide. Where such rivers collide, research suggests that the water flow speeds up and two downward-moving spiral currents form that scour a hole in the riverbed, just downstream of the junction. The two rivers are usually completely mixed within a few channel-widths downstream. We wanted to see whether this picture of flow structure simply scales up in much larger rivers like the Rio Paraná and Rio Paraguay.

Aerial photos immediately showed that the fairly clean Rio Paraná and silt-laden Rio Paraguay don't mix quickly, but what was going on underneath?

By using the very latest technology, including a RESON SeaBat multibeam echo sounder, we could measure the full three-dimensional shape of the riverbed down to a few millimetres, precision. The instrument beams sound onto the riverbed from over 200 individual elements at up to 50 times a second, and measure the reflections. As the research vessel moves along, you get a detailed view of the bottom of the river, as if all the water had slowly drained away, leaving it undisturbed. Our multibeam images are the first ever produced for a large river junction.

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We discovered a mighty scour hole, 35m deep, just upstream of the junction itself. The water flow gets constricted as it enters the confluence, gouging the depression. We could record sand dunes migrating into, around, and through this huge hole, and measured water flows close to an astonishing two metres per second along its base, whereas at the surface the flow was a leisurely 0.2 metres per second.

Surprisingly, the scour hole and its fast-flowing bottom water actually drive water upwards as the two river flows collide, in complete contradiction to the findings from studies of smaller rivers.

We're also finding that differences in the density of water in colliding rivers (as here where the two rivers carry different amounts of sediment) partly control how fast they mix. So we need to be cautious when scaling up from smaller rivers. Size really does matter!

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