

Taking a step back

Malindi Watamu Biosphere Reserve in Kenya and Braunton Burrows–North Devon’s Biosphere Reserve in the UK have a lot in common. They may be thousands of kilometres apart with very different climates but they share similar problems. Although one coastline is dotted with coral reefs, sandy beaches and mangroves and the other with marshlands, dunes and popular surfing beaches, both are in the frontlines of the battle being waged against the elements. Sea-level rise and erosion are eating into their beautiful coastlines, threatening the economy and people’s livelihoods. The wildlife habitats and beaches that are a draw for tourists are being threatened not only by these natural phenomena but also by unsustainable development. Last year, the communities of Malindi Watamu and North Devon decided to engage in an experiment. By twinning their biosphere reserves, they hope to learn from one another how best to adapt to their changing world.



Clovelly, a typical north Devon fishing village clinging to the eroding cliffs. Around 60 000 of the biosphere reserve’s 150 000 inhabitants live within 1 km of the coast and estuary.

Sea level is rising around the world. It will be impossible to stop this phenomenon, yet in north Devon in the UK, that is exactly what some residents are still hoping to do.

Research done in the UK indicates that there is a risk of losing 20% of important intertidal habitats to sea-level rise over the next 20 years. These salt marshes will need to be replaced because they provide important defences against flooding. If you have a salt marsh in front of a sea wall, the sea wall doesn’t have to be nearly as big or resilient because the salt marsh actually takes the energy out of the waves and the tide, as they beat against those defences.

In North Devon, the biosphere reserve team worked with Professors John Pethick and Julian Orford to identify what occur specific changes might be to

the estuary and its flanking coastline in the next 100 years. Residents were involved in the process to ensure an essential mix of local knowledge and scientific understanding. The results of the study were alarming. They shot down previously held theories of how the coastline had formed, the causes of existing problems and the way in which these should be managed. The shape of the coastline was likely to undergo a radical change, the study revealed.

To come up with these new conceptual models – which will need further testing –, the scientists produced a dataset for the current shape of the estuary and coast using LiDAR (Light Detection And Ranging), coupled with bathymetric studies to develop a single digital elevation model of the estuary basin in 3D. Pethick’s particular approach to the model uses the expected change in the volume of water entering the estuary as a result of rises in sea level as the main factor in altering the geomorphology of the estuary. Since the models of both the Intergovernmental Panel on Climate Change (IPCC) and the UK Met Office suggest there may be more intense



The beach at Instow, where the Taw and Torridge rivers converge into one estuary system before heading out to sea. The coast of the biosphere reserve is composed of a large bay that incorporates this estuary flanked by two large spits. One of these spits is the 1300 ha Braunton Burrows Dune system. The other is Northam Burrows (250 ha), which has less sand accretion and includes large areas of low-lying marsh fronted by a pebble ridge.

winter rains in future which would in turn increase river flow, Pethick's model also builds in these phenomena. It is obvious from this 100-year model that it is time to take a step back and let the natural processes take their course along the North Devon coast.

Flooding farmland

As with many estuaries, the Taw–Torridge estuary in North Devon is characterized by development around the periphery and agricultural land-use behind some of the flood defences. A number of exemplary salt-marsh habitats and exposed mudflats stretch in front of these flood banks. We have a classic case here of 'coastal squeeze', where rising sea levels will reduce the intertidal area in front of the defences. These areas provide services such as fish nurseries and wave energy dissipation. Their loss will have a knock-on effect in financial terms and pose a threat to property.

The biosphere reserve team has begun replacing some of the salt marshes. This has entailed reflooding river-side farmland, a project that has gone ahead uncontested. However, the re-recommendations for abandoning the mouth of the estuary to the sea have provoked the local ire.

Giving up pebble ridge

The south side of the estuary is protected by a huge ridge of grey pebbles. In recent years, during storms at high tide, the waves have moved pebbles on quickly at certain points, creating a gap in the ridge. The waves have also begun pummelling the dunes behind the beach. In the past, the council would repair the ridge by moving pebbles into the gaps with heavy machinery. But in the past few years, this costly and damaging policy has been dropped, allowing the sea to



Pupils from Bideford College taking measurements of the pebble ridge. Sophie Bosworth is holding the clipboard. The girl facing her is holding a clinometer, a standard geography field device for measuring the angle of inclination of a slope. The girls in the background are holding calipers; these are used to measure the size and flatness of the pebbles both along the ridge and up and down the face.

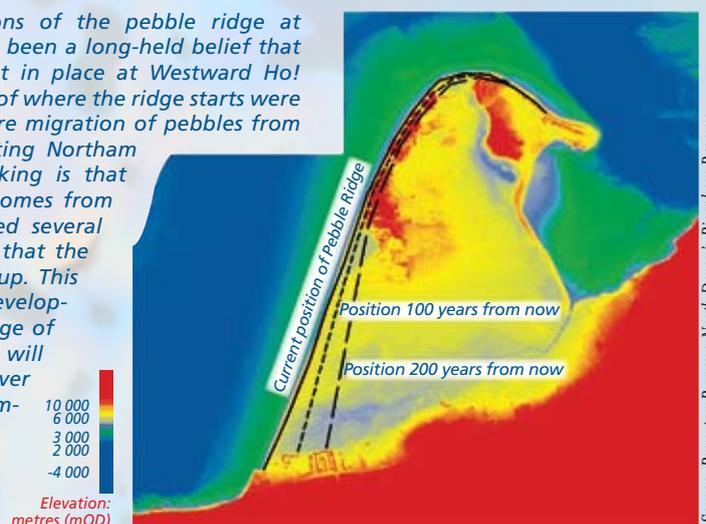
flood the land behind, known as Northam Burrows. Local councillor Andrew Eastman thinks this is wrong, a point of view shared by many disgruntled residents. 'We need to rebuild the ridge now,' Eastman says, 'to prevent the water from inundating the coast and buy us more time.'

However, this expensive solution is simply not sustainable. This is clear from the modelling done for the next 100 years using LiDAR data and other geomorphological indicators like the ancient raised beaches left behind from when sea levels were much higher in previous interglacial periods. As local geologist Peter Keene recalls, Northam Burrows has disappeared many times in the past – sea level rose by 8 m some 125 000 years ago – and will do so again. One of the casualties of the changing nature of the pebble ridge is likely to be the local golf course, an eventuality that sorely chagrins the community's golfers. On advice from the biosphere reserve team, the golf club has begun reconfiguring its course to accommodate the encroaching sea.

Getting people to decide with their heads

For many people living in a developed nation, the term 'climate change' evokes accelerating desertification in the Sahel or stronger monsoons in India. They perceive the likely severest effects of climate change as being too remote and too slow-moving for there to be any urgency to act closer to home.

Expected future positions of the pebble ridge at Northam Burrows. It has been a long-held belief that old coastal defences put in place at Westward Ho! immediately to the west of where the ridge starts were preventing the long-shore migration of pebbles from forming the ridge fronting Northam Burrows. The new thinking is that this supply of pebbles comes from a landslide that occurred several hundred years ago and that the supply has simply dried up. This has coincided with development of the coastal village of Westward Ho! The ridge will change its orientation over time to face the most common waves directly.



Source: Braunton Burrows-North Devon's Biosphere Reserve

Getting people to understand that 2.5 mm of sea-level rise per year actually means a lot when you total that up over the years is no easy task, especially when you tell them that it will accelerate over the coming years. People often react with their hearts rather than their heads when it comes to making difficult

decisions like whether or not to abandon land to the sea. Placing the time horizon for the impact just beyond the life expectancy of the current community de-personalises the issues and can give people the space they need to develop an adaptation policy that their children or grandchildren might appreciate.

It is the young who seem best able to think ahead. Pupils from Bideford College have launched a school project to measure the extent of sea-level rise on their local beach and at the pebble ridge. They take photos and have designed a website they call The Big Climate Thing,¹ to inform the public. The project ‘has made me aware of how climate change is affecting our local area,’ says teenager Sophie Bosworth, a pupil at Bideford College. ‘Especially by the river and by the beaches. We’ve been looking at the pebble ridge and how it has been retreating, how the sea is eroding it and causing this change and what effects it will have on the land behind it.’

Trouble in paradise

Meanwhile, in tropical Malindi Watamu Biosphere Reserve on the Kenyan coast, all eyes are turned towards the mangroves and beaches. In the reserve, embayments with large mangrove forests provide the same functions as the temperate salt marshes in north Devon: fish nurseries and the dissipation of wave energy. The Sabaki River discharges into this part of the coast but carries with it sediment from the soils eroding in the catchment behind, stifling the corals. This source of stress comes on top of a rise in sea temperature and the threat of acidifying oceans. Sea-level rise combined with possible over-abstraction of freshwater along the coast has also led to reports that some of these wells are increasingly saline due to seepage of the sea through the permeable limestone.

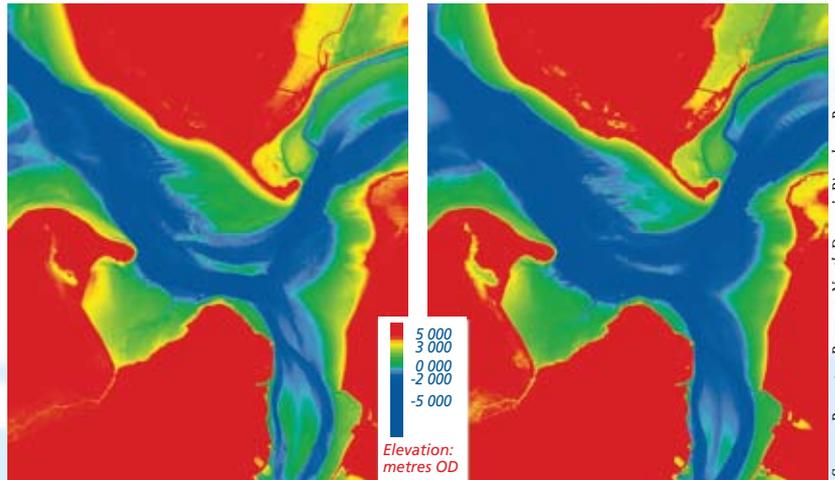
Coastal squeeze from both directions

Kenya benefits from legislation that safeguards a 30-m strip of the beach above the mean high-water mark for preservation. It is in this area that sea turtles nest. The strip also provides a good buffer against any increase in monsoon storms in the Indian Ocean.

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The community now takes protecting turtles seriously. When disaster strikes and one is found drowned in a fishing net, like here, it is given a dignified burial on the beach.



These two images show the loss of foreshore after 1 m of sea-level rise alone, not accounting for any increased erosion. Left is the situation today

Source: Branton Burrows-North Devon's Biosphere Reserve

However, we are witnessing the erosion of this strip. This is being caused both by the sea and by a worrying increase in unregulated development on land which is encroaching on the beach. The same symptoms of ‘coastal squeeze’ are happening here but from both directions!

Steve Trott, Chairman of the Watamu Marine Association, observes that erosion on Watamu’s Marine Park beach, one of Kenya’s main turtle nesting beaches, has been especially rapid since 2004. ‘So now the turtles are forced to nest in this ever-narrowing part of the beach that gets flooded,’ he says, ‘where the nests are in danger of being washed away and destroyed.’

Just like in Britain, feelings run high when it comes to protecting the coastline and wildlife. The Malindi Watamu Biosphere Reserve Organisation has joined forces with the Watamu Marine Association to ensure that the law safeguarding the 30-m strandline is upheld. The Association has already successfully pleaded its case to a National Environmental Tribunal to prevent the development of tourist villas at Blue Lagoon, an exquisite natural bay.

Enlisting the help of the population

It is not just the impact of sea-level rise that has the biosphere reserve management committee worried in Malindi. The main problem is poverty. It spawns mangrove deforestation, poaching and overfishing, even

though mangroves are the hatcheries for the fish which locals catch and provide vital building materials.

FAO estimates that 50% of the total mangrove forest has been lost along the Kenyan coast. Some has been cleared for agriculture and housing, some destroyed to produce salt factories and some polluted by oil spills. The Mida Creek Conservation Community Group and others have been working in the biosphere reserve to replant some of the mangrove areas. The population is being encouraged to take an active part. The fact that tourists are flocking to the area to see migratory birds like flamingos is an added incentive. Residents are also looking forward to being able to catch more fish thanks to the replenished nurseries.

The situation is not without conflict, as passionate local community groups try to stem the tide of uncontrolled coastal development and stop destructive illegal fishing and mangrove-cutting. The Malindi Watamu community seems to be far more in touch with the value and the services that their ecosystems provide and therefore more willing to work with them. Perhaps this is what Kenya has to offer the UK.



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Local people replanting mangroves under the watchful eye of the TVE camera



© Andrew Bell

Fishermen with their nets in shallow water at Malindi

Narrowing the technology gap

The Malindi Watamu committee would like to obtain more information and data on climate change in the biosphere reserve but does not yet have the resources to model the impact of sea-level rise. The teams from both biosphere reserves hope to raise at least US\$150,000 to enable them to obtain LiDAR and bathymetry data for the area and establish both more robust monitoring systems and participative management. In the meantime, the biosphere reserve team in Malindi Watamu has set up simple monitoring regimes which will help in modelling this stretch of coast once funding can be found.

The large-scale climate models and IPCC reports give some indication of what to expect but we also need a more local understanding of the impact of climate change, in order to adapt before it is too late. This is even more urgent for developing countries, which are likely to bear the brunt of climate change. There is no time to lose in strengthening collaboration between countries which have the technology and those which do not. The UK Met Office has provided sub-Saharan states with training on how to use Precis, a downscaling tool for the large climate models. The application of Precis models, LiDAR and other tools will help countries start planning their future.

To conclude, just as a surfer sees a wave approaching, anticipates its behaviour then rides it to make sure it does not kill him or her, biosphere reserves can help society to learn to ride the unfurling wave of climate change.

Andrew Bell² and Paul Makenzi³

For a map of Braunton Burrows–North Devon's Biosphere Reserve, see page 6.

The work in the twinned reserves has been captured by TV Trust for the Environment (TVE) and broadcast this year on BBC World, a production financed by UNESCO and the European Union. The full 22-minute DVD of *Rising Tides* is available in English and French from UNESCO: a.candau@unesco.org. It may also be viewed here: www.unesco.org/mab (click on Multimedia).

See also: www.northdevonbiosphere.org.uk

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1. *The Big Climate Thing:* www.bideford.devon.sch.uk/climatelab/page4/index.html
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