

Between land and sea

Geographer Thorsten Balke and his team are on a mission to protect intertidal zones and their dynamic ecosystems. The researchers have developed their own measuring devices to identify which areas are best suited as habitats for specific biotic communities. A visit to this unique landscape.

By Ute Kehse



Daniela Meißner (left) and Alejandra Vovides search for sensors in an oyster bed in the tidal flats near the coastal resort of Horumersiel.

If you trudge across the mudflats off Horumersiel on the west side of the Innenjade tidal channel at low tide on a calm day, the first thing you notice is the peace and quiet: no noise from traffic or building sites, not even the sound of waves or bird-song – just the occasional call of an oystercatcher. Everyday life on land seems very remote out here in the middle of this huge expanse of sand and mud.

Further out, however, the scenery changes and an astonishingly diverse world emerges. Large, sharp-edged Pacific oyster shells protrude from the sludgy surface – just the odd one here and there at first, then in ever larger clusters that alternate with piles of mud and small pools of water for as far as the eye can see. The rough shells of

the molluscs are covered with barnacles, tiny snails and even mussels. Fish larvae, transparent shrimp and small crabs dart across the puddles.

One wrong step here and you're ankle-deep in mud or scraping your shoes on sharp-edged oyster shells. "It's better to simply step directly onto the shells. Don't worry, the oysters won't mind," Dr Alejandra Vovides tells the two people accompanying her and technician Daniela Meißner on a field trip on this sunny day at the end of June. The ecologist moves effortlessly across the difficult terrain. "I've been working in intertidal zones for ten years now," she explains. From mangrove forests in tropical countries like Mexico or Indonesia to the salt marshes of the River Clyde in Scotland,

she has studied tidal flats and their ecosystems all over the world.

Vovides is a member of the Vegetation Ecology and Conservation research team, which is led by Prof. Dr Thorsten Balke and focuses on coastal wetlands that emerge for several hours at low tide. Sand, rock or fine silt form the substrate of these unique transition zones between land and open sea. This is a world of extremes, characterised by changing tides, fluctuating temperatures and salinity levels, powerful currents and a plentiful supply of nutrient sources. Depending on the climate and tidal currents, a variety of ecosystems thrive in these intertidal zones: mussel beds, seagrass meadows and salt marshes in the Wadden Sea; coral reefs, seagrass meadows and

mangrove forests in the tropics. One thing they all have in common is that they are endangered by a variety of factors, including pollution, fishing and climate change.

Balke's team aims to bolster efforts to conserve and restore these biotic communities by finding out which environmental conditions are most favourable for which ecosystems. This involves measuring variables such as how long a specific zone is flooded, how strong the current is at high and low tide, with what force the waves churn the water over the flats and how extreme conditions become during a storm. To gather all this data, in 2018 Balke began developing small, low-cost sensors similar to the accelerometers in smartphones for long-term

monitoring on the tidal flats. In the meantime, the team has calibrated and tested three designs for different applications. "Because existing hydrological sensors are too expensive and too big for our purposes, we decided to take matters into our own hands and refine the technology ourselves," says Balke. In an article published in 2024 in the journal *Limnology and Oceanography Methods*, Balke, Vovides and other researchers presented an updated design for their "Mini Buoys", together with an open-source app that analyses the gathered data.

The sensors are now distributed across the tidal flats off the North Sea resort of Horumersiel – each well sealed in a black plastic tube around ten centimetres long. Today, Vovides

and Meißner are on a mission to retrieve and replace four of the Mini Buoys out in the oyster beds and the shoreward mudflats. Their work is part of the German-Dutch SedWay project (Safeguarding the natural sediment processes in the Wadden Sea for biodiversity and people), which is led on the German side by Prof. Dr Bernd Siebenhüner, an environmental economist at the University of Oldenburg. The Lower Saxony Wadden Sea National Park Authority and the University of Groningen are also involved. "Our goal is to understand the hydrological landscape and create a fingerprint of the various habitats," Vovides explains as she makes her way across the oyster beds. The ecologist has positioned a total of 70 sensors at different locations



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- 1 The sensors are enclosed in plastic tubes that are anchored to the ground and float to the surface at high tide. Barnacles have colonised the casing.
- 2 Where's the next sensor? Alejandra Vovides recorded the coordinates of all the sensors, but she still has a hard time locating the little tubes.
- 3 The raw data documents the changes that occur between high and low tide. This information can also be used to track tidal current velocities.

between the islands of Terschelling in the Netherlands and Sylt in Germany, each of which has to be replaced every few weeks.

"The first sensor should be here somewhere," she says after a 20-minute march across mud and shells. According to the GPS, she's in the right location now, but all she can see far and wide is oysters. Only after a long search does she finally discover the small tube. A closer look reveals why the sensor was so hard to find: the black plastic casing is covered with tiny, grey barnacles that make it barely distinguishable from the surrounding oyster shells – an unexpected problem which Vovides hadn't yet encountered on her deployments in the salt marshes. "Now we'll have to do tests in the lab to determine whether this growth affects the buoyancy," she says.

Seagrass meadows are biodiversity hotspots

The Mini Buoys are attached by two keychain rings to a metal stake which is firmly lodged in the mud. At high tide, the sensors float upright in the water; at low tide, they lie more or less horizontal on the ground. In their study, the researchers were able to demonstrate that the devices record the desired data on the duration of tidal inundation and tidal current velocity with a high degree of accuracy. Now, thanks to a design update, they can also measure the force of the waves as they roll over the tidal flats.

The data will be fed into a Decision Support System (DSS) – a key result of the SedWay project, designed to help identify potential threats to the Wadden Sea ecosystems and plan measures for restoring lost biotic communities. One main focus here is seagrass meadows – an ecosystem of grass-like aquatic plants that thrive in water up to ten

metres deep. Today, little remains of these biodiversity hotspots, which were apparently once widespread in the Wadden Sea. Seagrass meadows filter the water, bind large amounts of carbon dioxide and contribute to coastal protection. "Before the 1930s, the East Frisian Wadden Sea was probably home to extensive seagrass meadows," Balke says. Since the 1970s, however, the remaining populations have experienced a sharp decline, mainly due to the large amounts of fertiliser carried by rivers into the North Sea. "Only near Sylt are there still a few larger patches," he adds.

Despite the fact that nutrient levels have dropped again in certain areas, attempts to reintroduce seagrass have had mixed results, possibly because they were carried out at the wrong time or at sites where this plant cannot thrive. "Our aim is therefore to gain a better understanding of what the dynamics in the system should be: what current velocities allow seedlings to colonise, how long can a certain area remain dry?" says Balke, who faces similar questions in his research on mangrove forests – the highly diverse ecosystems consisting of salt-tolerant

trees and shrubs that are typical of tropical intertidal zones. "I find it fascinating that the processes in these two systems are actually very similar," says the researcher, who has studied mangroves in Indonesia, Vietnam, Thailand and New Zealand, while always taking account of social factors that determine the success or failure of nature conservation measures. His doctoral thesis already focused on the hydrodynamic conditions needed for mangrove seedlings to grow on mudflats. Mangrove seedlings face the same challenges as plants such as marsh samphire in the salt marshes of the Wadden Sea – they need to take root within a relatively short time window in which the water level is low, and develop sufficient anchorage strength to avoid having their roots exposed or dislodged by the next storm.

The researchers refer to the period in which a germinating seed can take root undisturbed by tides as a "window of opportunity". How long it lasts can vary considerably at any particular location, because the tidal range is affected by the phases of the moon and the changing seasons. "With pioneer species in particular, it's impor-

tant to know how long they need to become established," Balke emphasises. In a recently published study, Balke together with Vovides and other researchers determined that two species of a globally widespread genus of mangrove trees have the best chances of thriving when the window of opportunity is at least three days long. In lab experiments, the seedlings developed branched roots up to twelve centimetres long within 21 days once the three-day period had elapsed. A high salinity in the substrate delayed growth, however. Field experiments in a natural environment in Sumatra confirmed these results.

Plans are underway to restore 600,000 hectares of mangroves in Indonesia in the coming years

The researchers believe their study could contribute to optimising the location and timing of mangrove regeneration projects in Indonesia,



The Mini Buoys were used for the first time in Sumatra (Indonesia) in 2019. The team led by Thorsten Balke (left) deployed 16 such devices in a former aquaculture basin that had been recolonised by mangroves.



Julia Brennecke

Organization and Leadership

Prof. Dr Julia Brennecke has been appointed Professor of Organization and Leadership at the School of Computing Science, Business Administration, Economics, and Law. Previously, she was Professor of Innovation Management at both the University of Potsdam and at the University of Liverpool (United Kingdom). She will remain associated with the latter institution in the future.

Brennecke studied social sciences at the University of Göttingen, completing her doctorate in business administration there in 2012. She then worked as a research associate at the University of Freiburg, completing her habilitation in 2017. Several of her academic positions were abroad, including at Swinburne University of Technology in Melbourne (Australia) and at the University of Liverpool (United Kingdom). As a visiting researcher, she spent time at the Sciences Po in Paris (France) and the University of Toronto (Canada).

Brennecke's research focuses on networks within and between organisations, particularly in innovation-intensive companies. She studies collaboration and knowledge transfer in networks among leaders, among other things. One of her current research projects looks at entrepreneurial households in sub-Saharan Africa and the networks they form.



Martin Bleichner

Translational Psychology

Dr Martin Bleichner has been appointed to the Heisenberg Professorship of Translational Psychology at the Department of Psychology, where he has headed the Emmy Noether Group 'Neurophysiology of Everyday Life', funded by the German Research Foundation, since 2019. With his project 'The Everyday Brain: Towards Capturing Temporal Dynamics Beyond Lab', he successfully applied for admission to the DFG's renowned Heisenberg Programme. The programme will cover the costs for the first five years of the permanent professorship.

Bleichner studied Cognitive Science at the Universities of Osna-brück and Utrecht (Netherlands). He completed his doctorate at the University Medical Centre Utrecht and moved to Oldenburg in

2013. From 2016 to 2018, the neuroscientist was an Associate Junior Fellow at the Hanse-Wissenschaftskolleg.

A central focus of Bleichner's research is the development of portable electroencephalography (EEG) devices that can be used to measure brain waves in everyday life. He intends to use this data to analyse how people perceive the world around them, and the roles that concentration, mood and attention play in this process. One focus is on the soundscapes of everyday life and the question of how the brain processes background noise, speech or music, for example.



Chih-Hong Cheng

Safety and Explainability of Learning Systems

Prof Dr Chih-Hong Cheng has been appointed to the professorship for Safety and Explainability of Learning Systems at the Department of Computing Science. Previously, he held an associate professorship in Software Engineering and Interaction Design at Chalmers University of Technology in Gothenburg, Sweden, where he continues to be active as a visiting researcher.

Cheng studied at National Taiwan University, where he earned his master's degree in electrical engineering in 2008. In 2012, he received his doctorate in computer science from the Technical University of Munich. This was followed by positions in government and industrial research, including at the Research Institute of the Free State of Bavaria for software-intensive Systems (fortiss). At the same time, he took on interim professorships in Munich and Hildesheim before accepting the call to Gothenburg in 2024.

Cheng's research focuses on the development of safe, autonomous systems supported by machine learning. To this end, he designs processes, algorithms and tools to detect errors at an early state and ensure correct execution. In addition, Cheng has developed the open-source-tool ComOpt for testing autonomous driving systems. For this, he was awarded first place in the AI testing competition organised by the renowned Institute of Electrical and Electronics Engineers (IEEE).

