



University of Algarve



OCEAN OBSERVATIONS TO STEM THE TIDES OF INVASIVE SPECIES IN THE GUADIANA ESTUARY

Researchers and citizen scientists in Portugal are working together to learn how to reduce the threat of invaders in the Guadiana estuary and wider Algarve region

The Guadiana river flows into the sea on the southern border of Portugal and Spain against a curious backdrop of estuary wilderness, fishing fleets, and high-rise resorts.

Away from the bustle of the tourist beaches, a patchwork of marshlands, creeks, and salt plains extend inland for more than 70 kilometres, providing estuary habitats for flamingos, spoonbills, Caspian terns, chameleons, and many other enchanting species.

Estuaries are shaped by seasonal and tidal cycles, and nourished by the undulating river flow. Dive beneath the surface, and an intricate combination of saltwater and freshwater creates gradients that cater for a wide diversity of needs: from crustaceans to lamprey to dolphins. The estuary environment serves as a vital nursery for fish and shellfish. Some inhabitants such as eels have even evolved to adapt their life cycles to survive and thrive in their ever-changing, nutrient-rich waters.

Yet, like many estuary habitats around the world, Guadiana faces myriad human-driven threats such as climate change, construction, sewage, damming, and agricultural runoff. These pressures are changing the composition of the waters and the species that call them home. As a result, the estuary has experienced profound shifts in its ecosystems – from the composition of plankton communities, to the arrival of invasive species such as blue crabs, grey sea trout, jellyfish, and pufferfish.



INVADER ALERT

There are a multitude of factors at play, from warming sea waters caused by climate change, to marine 'hitchhikers' in ship ballast tanks, to degradation of the estuary environment by human activities, and the reduction and regularisation of river flow.

Shortly before the turn of the millennium, plans were announced to create Western Europe's largest artificial lake through the construction of the Alqueva dam, some 150 kilometres upstream of the Guadiana estuary. Researchers at the Marine Sciences Centre (CCMAR) of the University of the Algarve realised it was a race against time to better characterise the estuary environment.

"The Guadiana estuary was already under a lot of strain from human activities and we were deeply concerned about the potential effects of the dam," recalls Alexandra Teodósio, an associate professor at University of Algarve/CCMAR. "There was an urgent need for a reference description of habitats and ecosystems in and around the estuary to understand how the dam might impact them. Without these baseline ocean observations it would be very difficult to understand and potentially mitigate some of the impacts."

Proponents of the Alqueva dam argued it would transform hundreds of kilometres of barren lands into agricultural pastures. Yet damming on such a large scale can come at a huge cost to the environment, such as a reduction in productivity in the lower estuary and nearshore, undermining key habitats and adversely affecting fisheries. Short on time, and with limited funding, Teodósio's team set up a sampling station in the lower Guadiana estuary that could monitor both the estuary's mouth and the plume of brackish water created when freshwaters meet marine.

The researchers collect key baseline data such as turbidity, temperature, salinity, and chlorophyll-a – a green pigment found in plant and algal cells that is essential for photosynthesis. "What we have seen through our observations is that the Alqueva dam has changed the intricate composition of the estuary waters," Teodósio says. "What was largely freshwater-dominated for much of the year is now, outside of wintertime and flood periods, mostly marine."



To gain insight into changes in the estuary ecosystem, the team turned to plankton - tiny organisms that form the base of aquatic food webs. "Plant-like phytoplankton are the ocean's main primary producers and are linked to the rest of the food web largely through their interactions with zooplankton - tiny animals that include single-celled grazers, crustacean, fish larvae, and jellyfish," says Teodósio. "Their composition can tell us a lot about the overall status of an ecosystem, as aspects such as the temperature, salinity, and nutrient content of the waters can play a major influence on their populations."

Almost as soon as the dam's gates were closed to fill its reservoir in 2002, the team began to see marked changes: reductions in chlorophyll associated with phytoplankton productivity, coupled with a sharp increase in gelatinous zooplankton.

"There used to be a large area in the middle of the estuary filled with different native species with high numbers of organisms adapted to the daily change of salinity from freshwater to salt water," Teodósio says. "But they disappeared after the dam construction and regularisation of the river flow, creating space for non-native marine species to settle without competition. Combined with other threats such as pollution and climate change, the estuary is becoming more vulnerable to changes in the ecosystem, and takeovers from invasive species."

With these observations, which are also shared with the global [Marine Ecological Time Series database](#), the group makes models and uses experimental water enclosures to try to identify interventions that could improve the situation. "One approach we are exploring could involve freshwater pulses that are delivered at the right times of year in order to simulate the seasonality of previous river flows," Teodósio says. "We are trying to understand the minimum of freshwater pulses and their approximate duration to restore conditions that native flora and fauna are used to. It can empower them to compete against invasive species. We hope with this research we can help develop a strategy to support native life in the estuary."



Depending on where you are in the world, well-known invasive species might span cane toads, elm bark beetles, Japanese knotweed, European rabbits, and black wattle. In the past four decades, their accumulated impact on the global economy was estimated to be [\\$1.3 trillion](#). Moreover, they are one of the biggest causes of biodiversity loss around the world. Due to a multitude of human impacts, such as shipping, aquarium releases, aquaculture, and climate change, plants and animals are also on the move in the ocean in ways they never would have been before. Yet many go under the radar, especially when hidden beneath the water's surface.



POWER OF PUBLIC OBSERVATIONS

Since the construction of the Alqueva dam, researchers have documented observations of invasive species in the Guadiana estuary thanks to a rather unconventional approach. "Fishers started providing information about changes in the estuary, mainly concerning animals they had not seen there before – including crustaceans such as crabs and shrimps, and fish," says João Encarnação, a PhD student in Teodósio's team at CCMAR. "Marine species can cause a wide range of disruptions at different levels, washing up on beaches, damaging fish catches, and causing turmoil in key estuary habitats. Learning how and why species are there, and how their populations might grow going forward, is essential for ensuring a sustainable future for the estuary."

But some sightings have taken the researchers by surprise. In June 2016, fisherman José Estica spotted a distinctive species of croaker known as a grey sea trout. Grey sea trout are native to sounds and estuaries of the North American Atlantic coast, and sightings off the Iberian Peninsula were virtually unheard of. Estica decided to contact the ECOREACH team who issued a press release about the sighting, encouraging others to come forward.

NEMA enables members of the public with close connections to the waters to help track invasive species – including subtropical species arriving due to climate change and trans-Atlantic ‘hitchhikers’.

“We think grey sea trout spent three to four years without being noticed by the scientific community,” Encarnação explains. “Biological invasions can often go unseen by the scientific community during the initial period of low numbers: and early detection by members of the public could help reduce impacts later down the line. It gives hope of reducing their effects on the natural food web. These are not just anecdotal findings: even just one or two sightings can be extremely valuable information.”

The success of such interactions inspired the launch of a citizen science project in 2019 encompassing the Guadiana estuary and the surrounding Algarve region called New Marine Species of the Algarve (NEMA).

“It allows us to cover larger geographical areas and fill gaps in the overall picture,” says Encarnação. “This can significantly reduce the time until first detection of invasive species and, when networks of observers extend far enough, track their dispersal.”

NEMA has been a big hit. ‘Most wanted’ posters complete with animal mugshots are shared on social and in traditional media to encourage people to report sightings of everything from Madeira rockfish, to barracudas, to mantis shrimp. Participants are asked to submit a photo, geolocation, and time of sighting via social media or an app. Over 400 records belonging to more than 45 species have been logged to date and, crucially, the initiative is helping researchers to understand the true scale of non-indigenous species, some with high invasive potential.

One example is the distinctive blue crab, an imposing looking native of the Gulf of Mexico, whose populations have recently been spiralling along the East Atlantic coast. Estuaries provide the perfect environment for blue crabs to flourish, where they can quickly multiply and devour almost everything they come across with their large claws and powerful jaws. Encarnação says that, prior to NEMA, there were just a few reports of blue crab seen in the Algarve region, all in the Eastern Algarve. But since the project was launched, large numbers have been logged from fishing nets, dive missions, or beach walks.

“Suddenly we had reports of blue crab across the entire south coast of Portugal,” Encarnação explains. “It is helping us to see changes in the natural environment first-hand. Similarly, when we hear reports of pufferfish in the Guadiana estuary or large turtles tens of kilometres upstream of where they would normally be seen, this information tells us that there are big changes going on.”

“We are trying to figure out which new species have come in, unravel where they have come from, and understand what changes they might have on the local environment.”



UNCONVENTIONAL CATCH

The ECOREACH team is also working with local people to try and find solutions. “One fisherman we worked with picked up a fireworm to take a photo and ended up with sores all over his hands,” Teodósio explains. “When fishers reported seeing a blue crab it was sometimes because they were afraid of it. We have been using such examples to raise awareness that people should take care.”

Teodósio says that the implementation of activities to control invasive species can also increase citizen engagement. One way the team are doing this is by working with fishermen and a local chef to raise awareness of their culinary potential. “These new species could be valuable to local fisheries,” she points out. “Many native species in the estuary are overexploited, and by catching them it could be possible to control their numbers and provide an income to fishers. On the other hand, species such as the blue crab and grey sea trout are endangered in their natural habitats. We need to balance that with understanding that these species may now have a space to survive.

“Personally, I have some mixed feelings about invasive species: these are new environmental conditions, caused by humankind. Some of these species are approaching our coast because of climate change, others we have introduced. In some ways it is important to take a step back and see what opportunities might be there and to try and get a better understanding of what is going on through our ocean observations so that we can also develop strategies to protect natural habitats in the estuary.”

