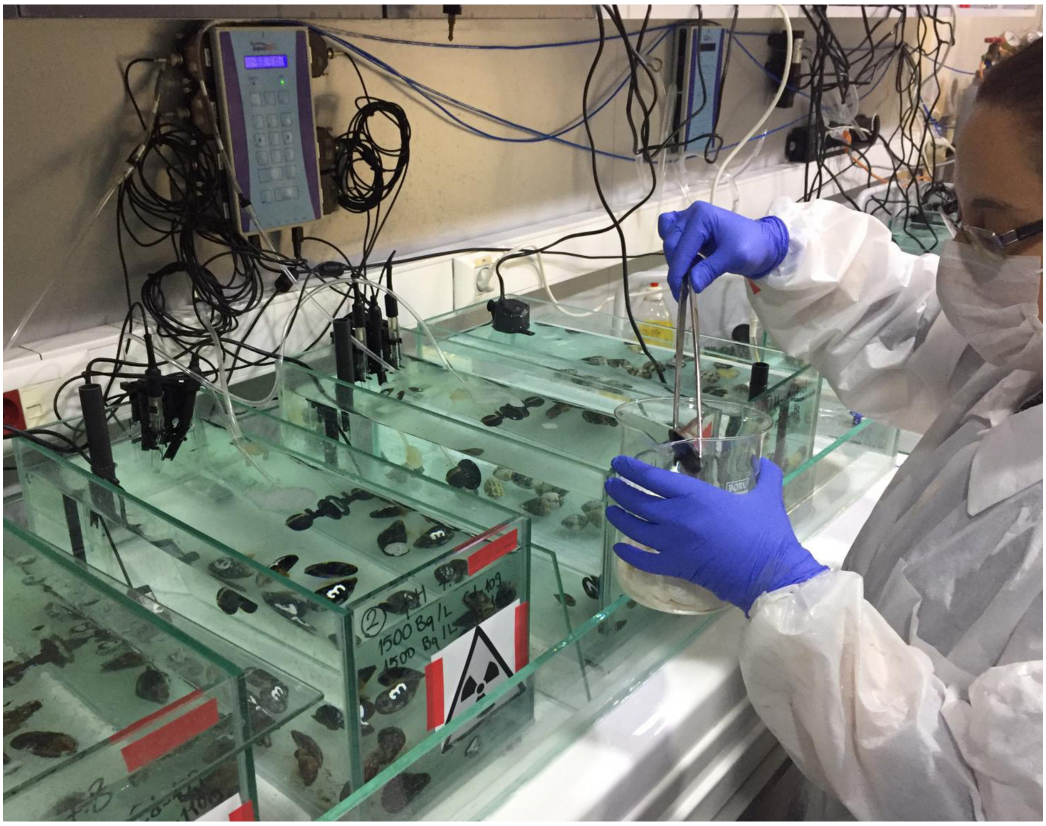
Jeopardy at sea: what atoms in clams tell us about ocean acidification

By Laura Gil



For scientists worldwide, marine organisms like clams, corals and tiny marine snails are a window into how CO_2 emissions are affecting the ocean.

(Photo: M. Belivermiş/Istanbul University Radioecology Laboratory)

Clams and other molluscs are under threat. As oceans gradually acidify due to rising carbon dioxide (CO_2) emissions, some of these marine organisms will find it harder to build their shells or skeletons. This is bad news not only for the organisms themselves, but also for the people who rely on them.

The good news? Scientists can use isotopic techniques to trace the atoms in these shell-building marine animals to better understand the impact of ocean acidification and climate change, which is a first step toward countering the problem.

"As ocean acidity levels increase, some organisms take up and accumulate more radionuclides or metals than others, grow more slowly, or need more food to survive. Nuclear techniques can trace all these effects," said Murat Belivermiş, a scientist at Istanbul University's radioecology laboratory who is using isotopic techniques to study the effects of climate change and ocean acidification on socially and economically important seafood. Belivermiş learned how to use nuclear and isotopic techniques during a fellowship in 2013 at the IAEA's Environment Laboratories in Monaco.

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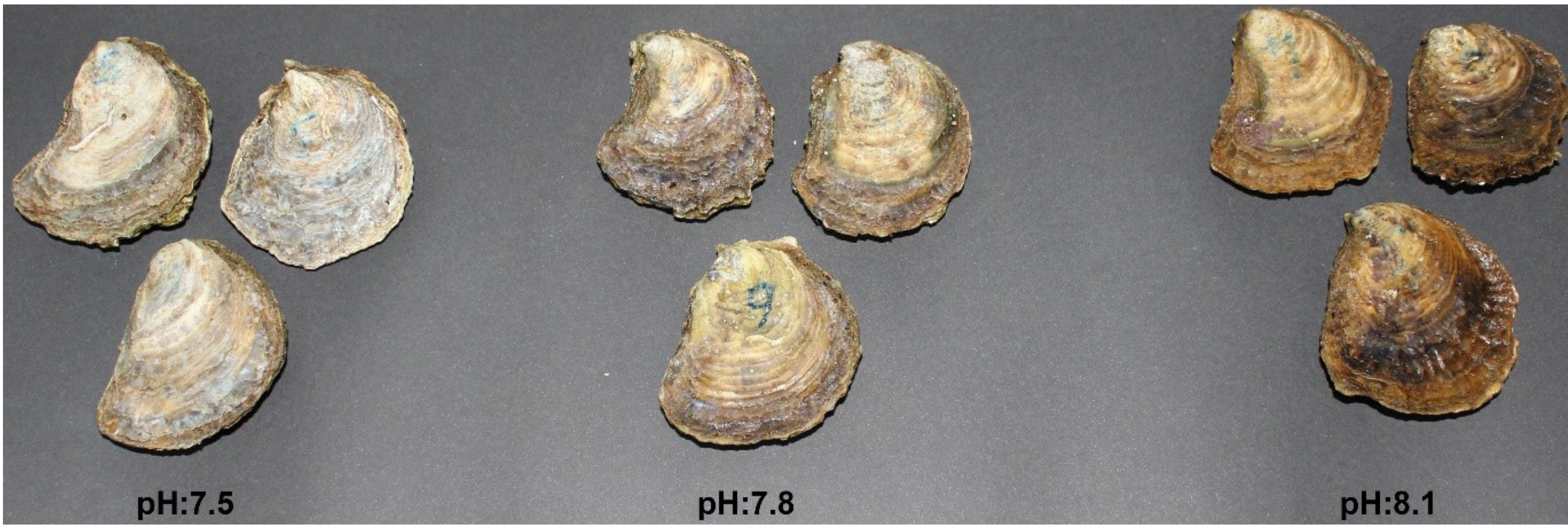
> *—Murat Belivermiş, scientist, Radioecology Laboratory, Istanbul University, Turkey*

For scientists worldwide, marine organisms like clams, corals, and tiny marine snails are a window into how changing climate conditions are affecting the ocean. Increasing CO_2 emissions — the propelling force behind climate change — are also accelerating ocean acidification. Oceans absorb about one-fourth of the CO_2 that the world emits into the atmosphere, changing seawater chemistry and, in turn, some marine ecosystems and organisms.

Nuclear and isotopic techniques are powerful tools that scientists can use to study ocean acidification, which is sometimes referred to as the 'other CO_2 problem'. Radioactive isotopes such as calcium-45 can serve as precise tracers to examine, for instance, the growth rates of calcifying organisms (see The Science box on page 16). These include mussels and clams that build their shells out of calcium carbonate, a naturally occurring mineral found in the ocean. Ocean acidification makes it harder for clams and



Oyster shells are bleached rather than destroyed by changes in pH levels: pH 8.1 is ambient conditions; pH 7.8 is estimated value in year 2100; pH 7.5 is estimated value in year 2300.

(Photo: N. Sezer/Istanbul University Radioecology Laboratory)

mussels to find the material they need to build and maintain their calcium carbonate shells.

Using radiotracers, Belivermiş and his colleagues discovered that, when exposed to slightly acidified seawater conditions, clams absorbed twice as much cobalt than they would under balanced control conditions, while other marine organisms, such as oysters, have shown a higher level of resilience. This reveals that ocean acidification not only poses a risk to the clams themselves, but also to the people who eat them; cobalt is a heavy metal needed by the human body in minute quantities, but is toxic at elevated concentrations. This can have wider socioeconomic implications for coastal communities like those in Turkey that rely on seafood for local consumption as well as for export to European countries.

"The fishery industry, including many aquaculture growers in Turkey, rely on certain species like clams. So this kind of research could help growers adapt to the changing conditions, which in turn would also help protect the country's fishery economy," Belivermiş said.

Belivermiş and his colleague, Önder Kılıç, are now working to expand their collaboration with the IAEA to study the long-term effects of ocean acidification on the growth, nutritional value and health status of species used as seafood in Turkey, such as the Mediterranean mussel or mullet.

"Mussel species live for up to two years," said Belivermiş. "In order for us to study the full life cycle of an organism, and to fully understand how it acclimates to acidified water, we need much longer experiments."

Understanding the long-term effects of ocean acidification

Much work lies ahead in order to understand the long-term effects of ocean acidification worldwide. Studies on marine organisms often last weeks to months, but grasping the more realistic effects of the changing ocean over time requires multigenerational studies.

A four-year IAEA coordinated research project to be launched in 2019 will bring together scientists to advance the understanding of the effects of ocean acidification on marine organisms in the long term. The project will aim to fill data gaps on economically and socially important seafood species, as well as explore adaptation strategies for aquaculture and seafood industries.

It will also help scientists understand the long-term effects of ocean acidification on essential nutrients in seafood, such as unsaturated fatty acids that benefit the human cardiovascular system, and what impact this could have on human health. Scientists will use both conventional and nuclear and isotopic techniques to study seafood species providing these nutrients, including oysters, mussels, shrimp, lobster, and fish.

"The oceans are on the one hand fragile, but on the other hand quite resilient. We have seen that they can recover if they are managed well," said David Osborn, Director of the IAEA Environment Laboratories. "What is important is that we recognize the threats we are putting on the oceans, their combined effect, and that we allocate resources to understanding those effects and addressing them in a proactive and effective way."

THE SCIENCE

Isotopic techniques and the effects of ocean acidification on calcifying marine organisms

Ocean acidification comprises a series of changes to seawater chemistry, such as a decrease in seawater pH, reflecting a shift towards increased acidity. These changes are measurable: since the onset of the Industrial Revolution, the average ocean pH levels have decreased by 0.11 pH units, equivalent to an increase of roughly 30% in acidity.

While it is difficult to estimate the full impact that ocean acidification may have on marine life, what is known is that, below a certain pH level and a corresponding carbonate concentration, conditions become corrosive to calcium carbonate, a key building block used by many organisms to form shells and skeletons. This can hinder their ability to grow shells and bones, making them fragile and lowering their chances of survival. Some corals, tiny sea snails (pteropods), clams and mussels (bivalve molluscs) and calcifying phytoplankton appear to be particularly sensitive to these changes.

Scientists use nuclear and isotopic techniques to study the rates of biological processes in marine organisms, such as mussels, oysters and corals. They trace specific isotopes, such as calcium-45 (Ca-45) or carbon-14, to understand these processes. Isotopes are atoms of the same element containing the same number of protons, but a different number of neutrons, giving them a different atomic weight.

For instance, scientists can use the radiotracer Ca-45 to measure the quality and rate of calcification, determining how fast and how well shells and skeletons are constructed. To do this, they add a known amount of Ca-45 into a seawater-filled aquarium that also houses, for example, clams. By measuring how much radiolabelled calcium carbonate ($CaCO_3$) is taken up by these organisms over time, scientists can evaluate this calcification process. They use this information to carefully assess the impact of ocean acidification.

(Photo: N. Jawerth/IAEA)