Scientist studies how ancestors of today's mammals responded to climate change

August 25 2014, by Marlene Cimons

Mark Clementz, associate professor in UW's Department of Geology and Geophysics, holds the lower jaw of a manatee from which teeth were sampled for stable isotope analysis. Credit: UW Photo

About 10 million years into the current Cenozoic Era, or roughly 56 million years ago, during a climate that was hot and wet, two groups of mammals moved from land to water. These were the cetaceans, which include whales, dolphins and porpoises, and the sirenians, with its sea

cows, manatees and dugongs.

Over time, their bodies began to adapt to their new environment. They lost their hind limbs, and their forelimbs began to resemble flippers. Their nostrils moved higher on their skulls. The cetaceans became carnivores, eating fish and squid, while the sirenians became herbivores, living on sea grasses and algae.

"It's an interesting example of evolution, and a natural experiment you don't normally have," says Mark T. Clementz, an associate professor of paleontology in the University of Wyoming's Department of Geology and Geophysics. "The changes are so extreme, you can't really ignore them. By studying these groups, we can tease out the main environmental factors that affect mammalian groups as they move into a new environment, and a new ecosystem."

The National Science Foundation (NSF)-funded scientist believes that understanding how the ancient ancestors of today's mammals responded to climate change will provide valuable insights that will help in dealing with environmental challenges.

"A better understanding of how these mammals responded in the past will give us a more informed idea of how they will respond to climate change in the future," Clementz says. "This could benefit conservation efforts down the road—for example, what to look out for, what things could benefit these groups, and what will hurt them if climate change goes as we project."

Moreover, "these mammals are like data loggers," he adds. "You can infer what the environmental conditions of the past were like, and how they changed over time, and you can say something about how marine ecosystems have changed over time."

The primary goal of his project is to compare the evolutionary ecology of these two orders, the Cetacea and the Sirenia, in the context of Cenozoic climate change.

The Cenozoic Era is made up of two time periods, the Paleogene and the Neogene, with each of those divided into epochs, which are smaller subdivisions of geologic time.

"With the appearance of whales and sea cows in the Early Eocene (the second epoch of the Paleogene), the evolution and diversification of both groups occurred across major episodes of significant climate change as the Earth moved from the greenhouse conditions of the early Paleogene and into the icehouse conditions of the Neogene, and today," he says.

Clementz conducts his research under an NSF Faculty Early Career Development (CAREER) award, which he received in 2009. The award supports junior faculty who exemplify the role of teacher-scholars through outstanding research, excellent education, and the integration of education and research within the context of the missions of their organizations.

To evaluate the impact of climate change on each group, Clementz examines fossil specimens of these ancient whales and sea cows as part of marine food webs. He analyzes the stable isotopes of calcium, carbon, oxygen and strontium, with an emphasis on, among other things, each group's ecological status, including diet and salinity tolerance.

"When we look at the sirenians, it appears that they had a relationship with sea grasses, which are found only in salt water, that extends far in the past," he says, noting that it is unusual for mammals to move from land to saltwater without first spending a transitional period in freshwater. "The isotopes suggest they were feeding in sea grass beds

while still capable of walking on land, and skipped the freshwater phase."

However, these conclusions may change upon examining recently acquired additional specimens.

"We now have some new fossils that imply that some sea cows might have been living in freshwater, but we haven't been able to fully analyze them yet," he says. Should that be the case, "it might have been a really fast transition," he says. "They might have spent a very short amount of time in freshwater, then moved quickly into a marine habitat."

The cetaceans, on the other hand, "do show a freshwater phase," he says.

Interestingly, the sirenians are very sensitive to environmental temperatures, staying where the water is warm—20 degrees Celsius (about 68 degrees Fahrenheit) or warmer. Today's global warming may, in fact, support them, but possibly only to a certain extent.

"They like it warm," he says. "In the past, when conditions were warm, their range was greater. They went farther north and farther south. So, from a temperature perspective, today's climate change warming could benefit them. There is some question about how the climate could affect sea grasses and algae. It could be worse for them if it hurts their food supply."

Cetaceans, being more diverse, are more complicated, he says.

"They have about 80 different species, compared to the sirenians' four," he says. "They have been more successful at taking advantages of changes. It could be related to their diet of fish and squid. In cooler environments, they had higher food productivity. They exploited those periods and diversified. Now that things are getting hotter, we're not sure

how this will affect them."

As part of the grant's educational component, Clementz is taking an integrative big-picture approach to teaching K-12 and college students the concepts of evolution, ecology and climate change.

For example, he wrote a children's play that explains what occurred during the evolution of whales. Later, with the input of a choreographer and dance instructor, the play expanded to include a dance recital. It has been performed multiple times on campus, and many outside groups of young children have seen it.

"The children studied the movement of whales, then learned about their movements through dance," he says. "They got to see how whales move, and how it affects their bodies, and they got to dance, using dance moves that simulate whale movement. Visually, it really was stunning, and the kids learned a lot this way."

Provided by University of Wyoming