

How Sea Turtles Have Weathered Past Climate Changes

By BRIAN W. BOWEN and BRYAN WALLACE

Climate change has become one of the hottest topics in international news cycles and has entered the lexicons of the public and policymakers. Although vast uncertainty remains about the timing and extent of climate change, there is growing consensus about the need to address its specter. While many scientists race to generate predictive models of future scenarios, understanding how natural systems have responded to past climate changes can also provide a valuable window on what's to come.

Ancestors of today's sea turtles roamed the oceans over a hundred million years ago, surviving conditions both much warmer and much cooler than those today. These fluctuations altered nesting beaches, foraging habitats, and numerous other environmental conditions affecting sea turtles. Despite all the changes, sea turtles swim on. Studies of how they responded to large-scale changes in Earth's climate could reveal what will be necessary for them to survive the forecast for the near future. A forensics team—"sea turtle CSI" (Crime Scene Investigators)—can combine evidence from past events with current knowledge of sea turtle life history into a coherent picture of what's possible for the future. For this information, we turn to unlikely sources: rocks, snails, penguins, and the history recorded in sea turtle DNA.

Some Like It Hot

How sea turtles select nesting beaches remains a topic of scientific curiosity with important implications for how sea turtles might respond to the future loss (and gain) of today's nesting beaches. All sea turtle species show different degrees of nest site fidelity. This tendency toward the familiar, coupled with the narrow temperature range needed for embryonic development—26°C–32°C (79°F–90°F)—indicates that sea turtles are indeed vulnerable to beach habitat loss that might occur under some climate change projections.

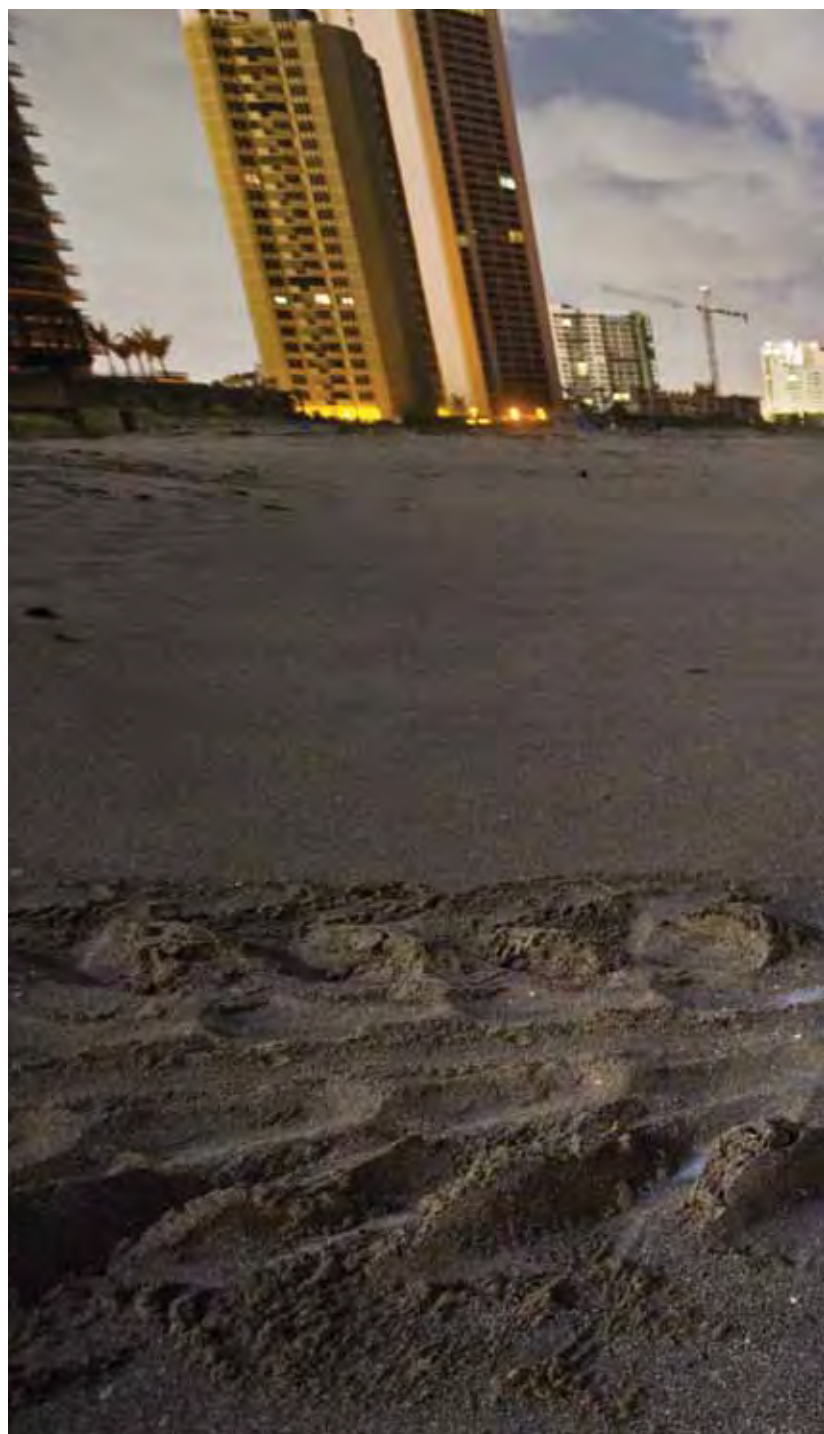
Ocean temperatures increased after the last Ice Age about 12,000 years ago. At that time, sea turtles might have nested at the southern tip of Florida, United States. Further north, the climate was too cold, as evidenced by fossil records showing that cold-water snails occurred in southern Florida, while today these snails occur much further north. Likewise, loggerhead turtle nesting spread northward after the last glacial period, to the present-day limit in Virginia. Around the same time, loggerhead and green turtles colonized the Mediterranean Sea, which had been too cold to support nesting during the Ice Age.

Such historical climate records demonstrate that sea turtle nesting can, over time, slide up and down along coastlines to accommodate the appropriate temperature range for egg incubation. Once an appropriate habitat opens up—like the Mediterranean Sea—turtles can colonize it within a few dozen generations. Archie Carr, the father of modern sea turtle biology, hypothesized that rare "gravid waifs" (females carrying fertilized eggs) might depart their natal nesting site to colonize a new habitat. In this way, sea turtles have been adjusting to natural climate change for millions of years.

Some Like It Cold

During glacial periods, some areas get colder than others, which can result in loss of habitat for sea turtles. For example, genetic evidence indicates that all sea turtles in the eastern Pacific Ocean are recent arrivals. The leatherback, olive ridley, and green turtles (and probably hawksbills) that presently nest and feed in the eastern Pacific are all descendants of colonists from elsewhere in the Pacific. So, why the recent colonization?

Cold water in the eastern Pacific Ocean extends well into the tropics and all the way to the equator during glacial periods, as shown by the world's northernmost presence of penguins on the Galapagos Islands, near the equator in the eastern Pacific. These cold-adapted birds followed a corridor of frigid water from Antarctica all the way to



the equator during glacial conditions. The conditions that favored expansion of the penguin's habitat also eliminated sea turtle nesting and feeding habitats in the eastern Pacific. To match this back-and-forth pattern of accessible ocean and beach real estate, sea turtles moved into and out of the eastern Pacific.

So, although warming conditions allowed sea turtles to extend their range into higher latitudes, colder conditions may have eliminated nesting in places like the eastern Pacific Ocean and Mediterranean Sea. However, as glaciers receded and oceans warmed, sea turtles readily re-colonized these areas. The lesson is that although a location might not be viable as sea turtle habitat today, wait until tomorrow (geologically speaking).

And Some Have Nowhere to Go

So far, we have seen that sea turtles can move into and out of regions in response to climate change and on a time scale of hundreds of turtle



Although sea turtle populations have responded to past climate changes by moving to new nesting beaches, coastal development limits the potential for sea turtles to respond similarly to current and future changes in their nesting habitats. © JIM RICHARDSON / NATIONAL GEOGRAPHIC STOCK PREVIOUS PAGE: Sea turtles have been swimming the seas for millions of years. They have outlived many of their reptilian brethren, like the mosasaurs and plesiosaurs illustrated in this mural of marine life during the Cretaceous period (144 million to 65 million years ago). Understanding how sea turtles responded to past climate changes could paint a picture of how they would survive threats from present-day climate change. © KAREN CARR

generations. They can adjust to warming trends by shifting their ranges into higher latitudes, but this shift is possible only on a sandy coastline. On most continents, higher latitude coastlines are dominated by rocky habitat with few beaches. Thus, as turtles move away from the tropics under future warming scenarios, they might have nowhere to go.

Furthermore, even when sea turtles can shift their nesting habitat, they could be imperiled not only by rocky habitat, but also by condominiums. In some areas, beachfront construction makes even sandy beaches unsuitable for sea turtle nesting. In anticipation of future climate change, adaptive efforts like coastal setbacks—inland tracts of land that are parallel to beaches and are left devoid of development—can build resilience into coastal areas and can buffer against loss of nesting habitat.

The Shifting Climate Means Shifting Habitat for Sea Turtles

Clearly, sea turtles are survivors. They have weathered radical climate changes in the past 100 million years. However, they have never faced anthropogenic changes of the scope and speed proposed for the coming decades. Researchers are working to understand the factors that will affect sea turtles under future scenarios, especially in forecasting habitat shifts. The persistence of sea turtles through previous climate crises tells us that they might not stay in the same places they are today. But if they have the appropriate time and space, they could continue navigating the oceans for another 100 million years. ■