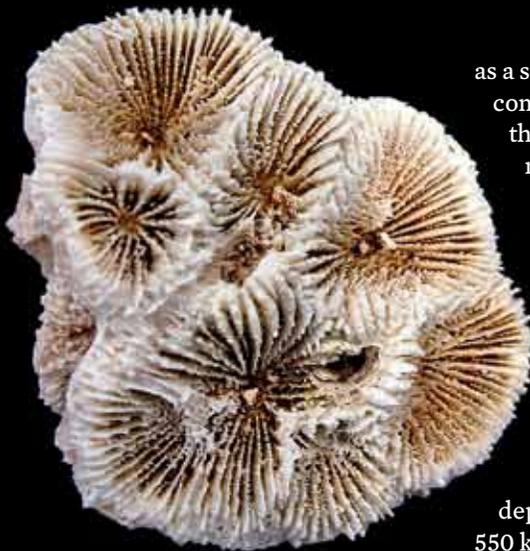


Reefs at the mouth of the Amazon River

The region where the river meets the ocean between the states of Pará and Amapá is home to the northernmost corals along Brazil's coast

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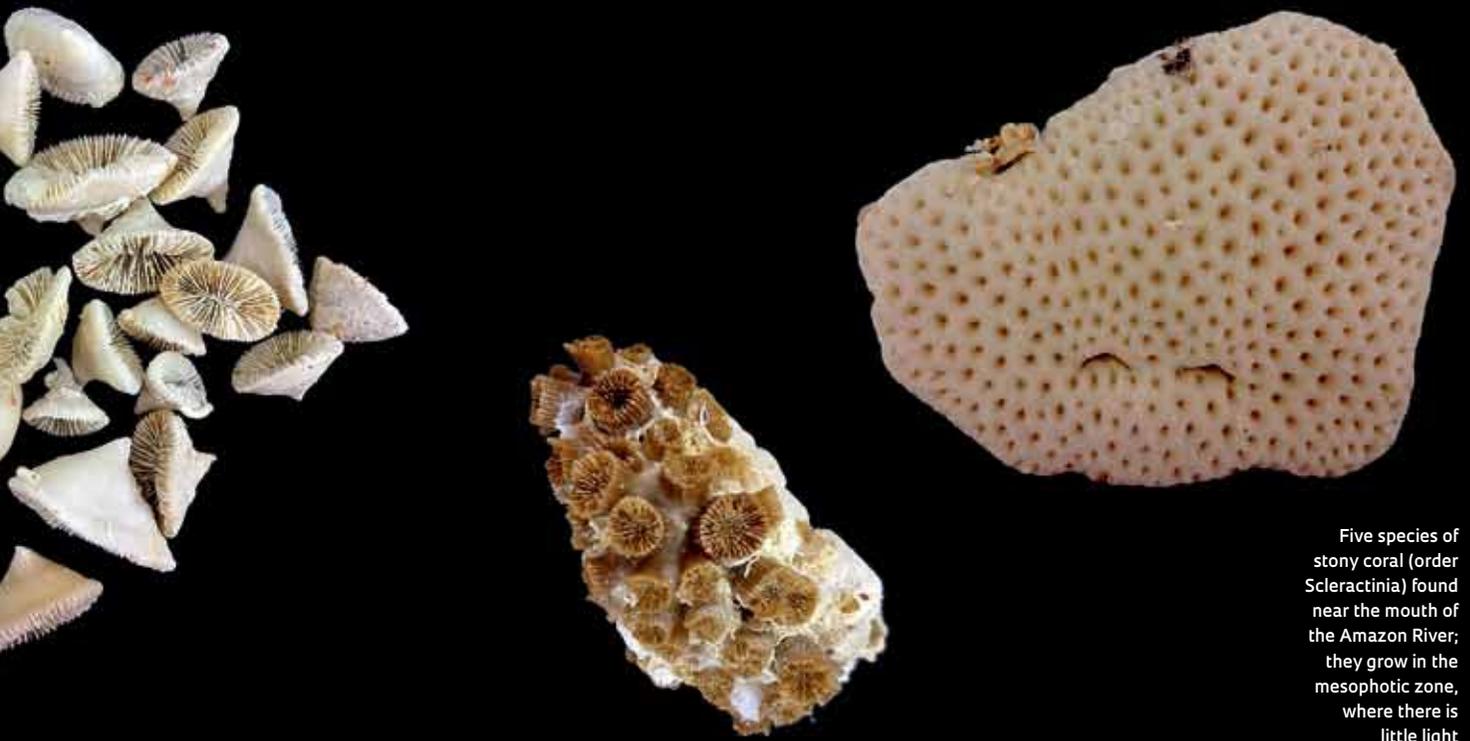
Approximately 86 kilometers from the coast of the state of Maranhão, the Parcel de Manuel Luís is the largest coral community in South America. Its reefs, situated at a depth of 15 to 45 meters (m), encompass an area of 9 square kilometers. Its submerged walls are allegedly responsible for the wreck of two hundred ships between the 16th and 20th centuries. Protected by its status

as a state marine park, the Manuel Luís complex is traditionally described as the northernmost occurrence of coral reefs along the Brazilian coast. This has now been called into question by a new study. According to a scientific article published in October 2015 in the *Bulletin of Marine Science* by biologists of the Anthozoa Research Group (GPA) at the Federal University of Pernambuco (UFPE), little-known reef communities are present at a slightly greater depth located approximately 550 kilometers (km) north of Manuel Luís. These reefs are found opposite the mouth of the Amazon river, between the states of Pará and Amapá. Most of the corals were found at depths varying from 30 to 125 m, along what is known as the mesophotic zone, which has a low incidence of light.

After reviewing the scientific literature on the topic and

searching the records on marine specimens collected since the 1950s near the delta of the world's largest river, the team concluded that there are at least 38 species of coral in this region. Most of the identified species (27) belong to the Octocorallia subclass (soft corals). These corals have eight tentacles on their polyps and include the gorgonians, blue corals and sea pens. Nine species are stony corals, also known as true corals (order Scleractinia); one is a black coral (order Antipatharia); and one is a hydrocoral, or fire coral (order Anthoathecata). The samples analyzed in the study are from the collections of the Dr. Petrônio Alves Coelho Museum of Oceanography, UFPE, and the Smithsonian National Museum of Natural History (USA). Specimens collected in the region during the Piatam Ocean project—carried out by Brazilian universities with Petrobras funding—were also identified. This project collected marine animals in the early 2000s along the coasts of Pará and Amapá.

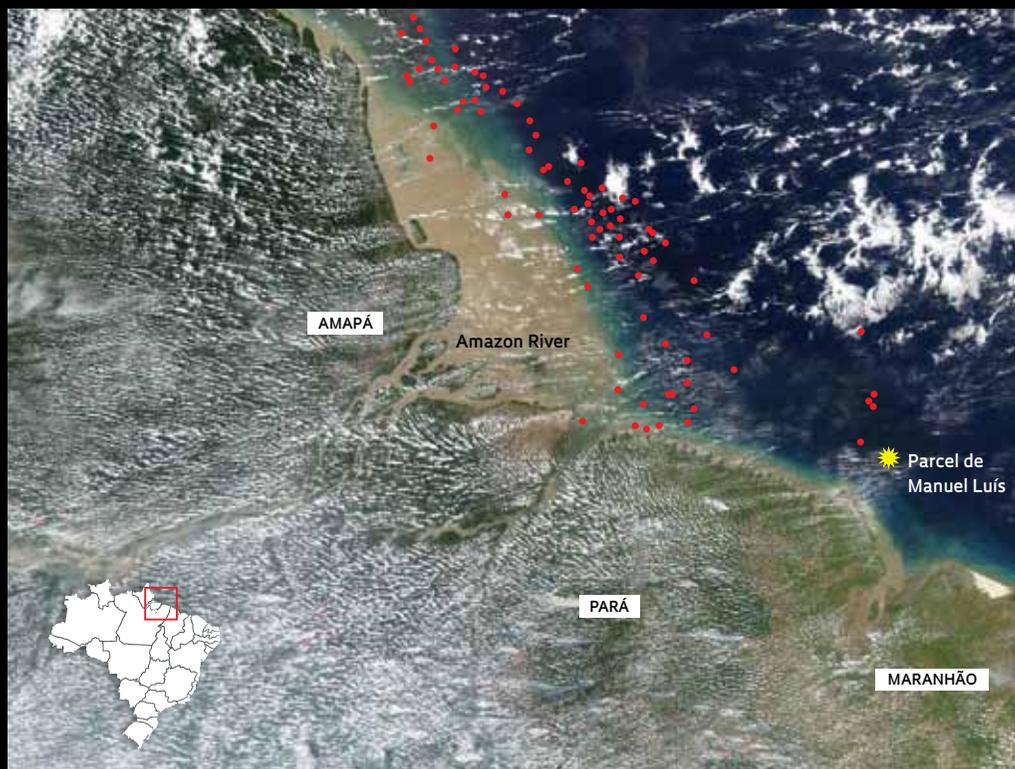




Five species of stony coral (order Scleractinia) found near the mouth of the Amazon River; they grow in the mesophotic zone, where there is little light

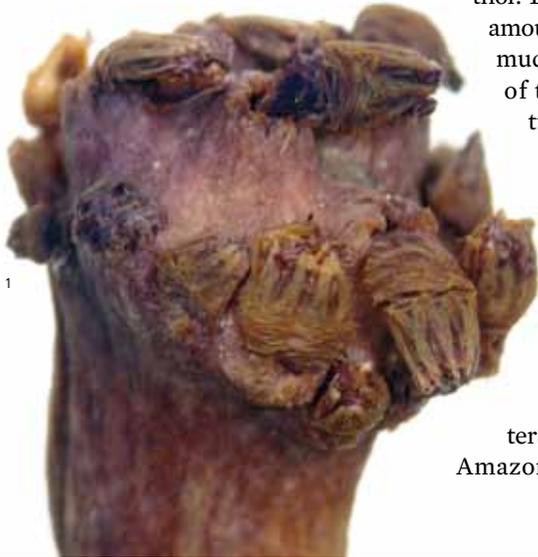
The location of the northernmost corals in Brazil

The formations are located north of the Parcel de Manuel Luís, 40 to 250 km from the coasts of Pará and Amapá



● Corals in the Amazon River delta

Nidalia occidentalis: one of the 27 species of Octocorallia found near the mouth of the Amazon River



The discovery of colonies of these marine invertebrates opposite the Amazon River delta, about 40 to 250 km from the coast, was a surprise. “Rivers are considered natural deterrents to the appearance of corals, and the Amazon River has always been seen as an important barrier to the formation of reefs,” affirms biologist Ralf Cordeiro, the study’s lead author. The Amazon carries an enormous amount of sediment to the ocean and muddies marine waters. The effect of the river on the ocean is captured in satellite images, such as the one used in this article to illustrate where corals occur in the north. With less light falling on its surface waters, the delta region is inhospitable to coral proliferation. The large amount of fresh water discharged from its mouth also significantly alters the salinity of the Atlantic. The Amazon accounts for 18% of all fresh

water flowing into the oceans and seas of the planet. All of this makes coral proliferation difficult. These living organisms occur in marine environments that must satisfy rigid parameters, such as salinities between 3.45% and 3.64% and temperatures between 24.5 and 28.3 degrees Celsius (°C). Earlier studies carried out in this region estimate that the influence of the water flowing from the mouth of the Amazon into the Atlantic can be felt at a distance of up to 500 km off the coasts of Pará and Amapá.

AN OASIS OF LIFE

The adverse local conditions likely explain the absence of corals in the shallower waters of the mouth of the Amazon River and the concentration of these marine invertebrates in deeper parts of the Atlantic. According to this scenario, the existence of reefs in shallow water would be almost impossible in this region. However, as the water deepens, there are gaps that permit oa-

The Antarctica-Abrolhos Connection

Climatic conditions induced by the hole in the ozone layer may be associated with the diminished growth of corals in southern Bahia State

The hole in the ozone (O₃) layer over Antarctica, which appears during spring in the Southern Hemisphere, may play an important role in a change taking place in the tropical Atlantic about 8,000 km to the north of the frozen continent: the reduction in the growth rate of coral reefs in Abrolhos, in the south of Bahia State, since the 1980s. A study by Brazilian, French and Taiwanese researchers published on August 17, 2015, in the *Biogeosciences Discussions* journal, suggests that there is a strong correlation between the two phenomena despite the enormous distance separating them.

According to the article, the hole in the ozone layer has intensified the winds from the west. Now stronger, they push more of the warmer surface water to the stretch of ocean near the northeastern coast of Brazil. Data from climate models

indicate that the average annual temperature of the waters in the south of Bahia rose 1°C, from 24.8°C to 25.8°C, between 1948 and 2006. Sensitive to the smallest variations in ocean temperature, the corals in Abrolhos, located about 40 km from the coast, have been growing more slowly in the past four decades.

“We tested several parameters that could be causing the heating of the water in Abrolhos, such as global warming and the El Niño phenomenon,” says geophysicist Heitor Evangelista of the Laboratory of Radiology and Global Changes of Rio de Janeiro State University (UERJ), the article’s lead author. “The best explanation for this change is the existence of the hole in the ozone layer, which modifies the winds from the west around Antarctica and thus the pattern of winds in the South Atlantic.”



To analyze the evolution of the Abrolhos reefs, the scientists collected three specimens of two species of brain coral from the region, *Siderastrea stellata* and *Favia leptophylla*. The samples were taken from healthy colonies and were obtained as witnesses, small vertical columns measuring 28 or 50 cm high that can be used to infer the growth rate of coral over time. Both species showed a decline in their growth rate, especially beginning in the mid-1970s and early 1980s. Although the hole in the ozone layer over Antarctica was only identified in 1985, its effects on the climate began earlier.

Collection of specimens from the Abrolhos reef (above) and representation of the hole in the ozone layer (at right, in blue) in Antarctica: A warmer Atlantic Ocean affects the growth of corals

ses of life to emerge. “Below a depth of about 25 m, the influence of the river’s sediment and fresh water diminishes, and conditions for corals improve,” explains Cordeiro.

The existence of deep-sea corals near the Pará and Amapá coastlines indicates a different pattern of occurrence than those found at points along the Brazilian coast where reefs are present. In Abrolhos, in the south of the State of Bahia, and even in the Manuel Luís community, these formations tend to be located in shallow waters at depths of up to 30 m. Some corals identified in the mouth of the Amazon River are endemic to Brazil and are able to build true reefs, such as the brain coral *Mussismilia hispida*. This indicates that there may be reef ecosystems of a reasonable size at intermediate



Parcel de Manuel Luís, corals in shallower waters than those off the coasts of Pará and Amapá

depths in that region, although there is currently no detailed information about their extent.

The UFPE researchers believe that most of the corals in the Amazon delta came from ancestral Caribbean populations. “There may have been—or still could be—a corridor of corals in the mesophotic zone between the Caribbean and the Atlantic,” says biologist Carlos Daniel Pérez, GPA coordinator, professor at the UFPE Vitória Academic Center and co-author of the study. Some studies suggest that the corals in Central America and northern Brazil were connected in

the remote past. One fact that supports this hypothesis is that more than half of the species of coral of the order Scleractinia found on the Brazilian coast are also found in the Caribbean. Most of the studies estimate that the marine fauna in the two regions diverged, in evolutionary terms, 5 to 16 million years ago, precisely when the Amazon River began to flow into the Atlantic.

STUDIES WITH VIDEO AND PHOTOS

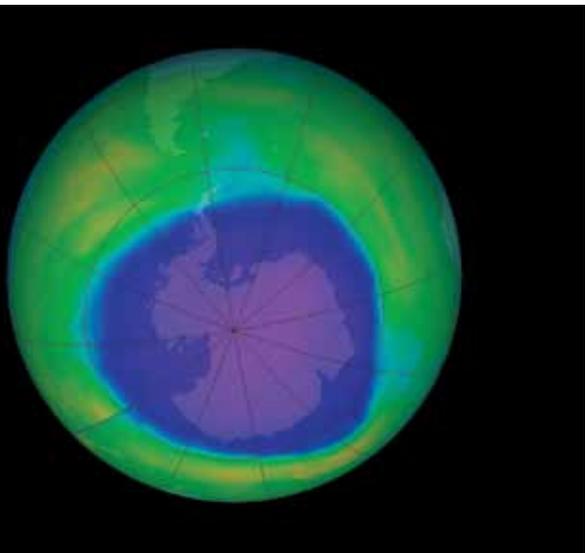
According to Alberto Lindner, a biologist at the Federal University of Santa Catarina (UFSC), the article written by Cordeiro and his colleagues at UFPE substantially increases our knowledge of corals in the vicinity of the Amazon River delta and discredits the argu-

ment that the Manuel Luís community is the northernmost boundary of the geographic distribution of these marine invertebrates along the Brazilian coast. “Despite prior research indicating the existence of sponges, reef fish and some species of coral at the mouth of the Amazon, the new study is surprising in that it reports unprecedented findings of more than 20 species of coral in this region,” says Lindner, coordinator of the Marine Biodiversity project of the State of Santa Catarina and a coral researcher.

Since this region in the Atlantic is difficult to access for the purpose of collecting specimens, the records of marine life at the mouth of the Amazon are incomplete. Muddy, turbulent water is a challenge for oceanographic studies and makes scuba diving difficult. The researchers believe that the work of characterizing the area will need to be done using remote-controlled submarine vehicles, given that there are corals at depths greater than 100 m. “Due to global warming, the acidification of the oceans and other threats to the corals, such as trawling, we recommend the region be photographed and video recorded so that we can better understand these severely neglected marine communities,” says Pérez. ■

Scientific Articles

CORDEIRO, R.T.S. *et al.* Mesophotic coral ecosystems occur offshore and north of the Amazon River. *Bulletin of Marine Science*. V. 91, No. 4, pp. 491-510. Oct. 2015. EVANGELISTA, H. *et al.* Southwestern Tropical Atlantic coral growth response to atmospheric circulation changes induced by ozone depletion in Antarctica. *Biogeosciences Discussions*. August 15, 2015.



The researchers involved in the study believe they have identified a climatic teleconnection—a phenomenon in one corner of the planet that causes repercussions in another part of the globe—with implications for the marine environment in southern Bahia. “The influence of Antarctica on atmospheric circulation is already known,” says Professor Ilana Wainer from the University of São Paulo Oceanographic Institute (IO-USP). “What is new is this impact on the tropical Atlantic, specifically in relation to coral growth.” A specialist in climate models for interactions between the ocean and the atmosphere in the Antarctic, Wainer is one of the paper’s co-authors.