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First-of-its-Kind Study Reveals Surprising Ecological Effects of Earthquake and Tsunami

The reappearance of long-forgotten habitats and the resurgence of species unseen for years may not be among the expected effects of a natural disaster. Yet that's exactly what researchers have found on the sandy beaches of south central Chile, after an 8.8-magnitude earthquake and devastating tsunami in 2010. Their study also revealed a preview of the problems wrought by sea level rise –– a major symptom of climate change.

In a scientific first, researchers from Universidad Austral de Chile and UC Santa Barbara's Marine Science Institute (MSI) were able to document the before-and-after ecological impacts of such cataclysmic occurrences. A new paper appearing today in the journal PLoS ONE elucidates the surprising results of their collaborative study, pointing to the potential effects of natural disasters on sandy beaches worldwide.

"So often you think of earthquakes as causing total devastation, and adding a tsunami on top of that is a major catastrophe for coastal ecosystems. As expected, we saw high mortality of intertidal life on beaches and rocky shores, but the ecological recovery at some of our sandy beach sites was remarkable," said Jenifer Dugan, an associate research biologist at MSI. " Dune plants are coming back in places there haven't been plants, as far as we know, for a very long time. The earthquake created sandy beach habitat where it had been lost. This is not the initial

ecological response you might expect from a major earthquake and tsunami."

Their findings owe a debt to serendipity. With joint support from Chile's Fondo Nacional de Desarrollo Científico y Tecnológico and the U.S. National Science Foundation's Long Term Ecological Research program, the scientists were already knee-deep in a collaborative study of how sandy beaches in Santa Barbara and south central Chile respond, ecologically, to man-made armoring such as seawalls and rocky revetments. As part of that project, the Chilean team surveyed nine sandy beaches along the coasts of Maule and Bíobío in late January, 2010. The earthquake hit in February.

Realizing their unique opportunity, the scientists quickly changed gears and within days were back on the beaches to reassess their study sites in the catastrophe's aftermath. They have returned many times since, diligently documenting the ecological recovery and long-term effects of the earthquake and tsunami on these coastlines, in both natural and human-altered settings.

The magnitude and direction of land-level change brought the greatest impact, drowning beaches especially where the tsunami exacerbated earthquake-induced subsidence –– and widening and flattening beaches where the earthquake brought uplift. The drowned beach areas suffered mortality of intertidal life; the widened beaches quickly saw the return of plants and animals that had vanished due to the effects of coastal armoring.

"With the study in California and our study here, we knew that building coastal defense structures, such as seawalls, decreases beach area, and that a seawall results in the decline of intertidal diversity," said lead author Eduardo Jaramillo, of Universidad Austral de Chile. "But after the earthquake, where significant continental uplift occurred, the beach area that had been lost due to coastal armoring has now been restored. And the re-colonization of the mobile beach fauna was under way just weeks after."

With responses varying so widely depending on land-level changes, mobility of flora and fauna, and shore type, the findings show not only that the interactions of extreme events with armored beaches can produce surprising ecological outcomes –– but also suggest that landscape alteration, including armoring, can leave lasting footprints in coastal ecosystems.

"When someone builds a seawall, not only is beach habitat covered up with the wall itself, but, over time, sand is lost in front of the wall until the beach eventually drowns," Dugan said. "The semi-dry and damp sand zones of the upper and mid intertidal are lost first, leaving only the wet lower beach zones. This causes the beach to lose diversity, including birds, and to lose ecological function. This is an underappreciated human impact on coastlines around the world, and with climate change squeezing beaches further, it's a very serious issue to consider."

Jaramillo elaborated, "This is very important because sandy beaches represent about 80 percent of the open coastlines globally. Also, sandy beaches are very good barriers against the sea level rise we are seeing around the world. It is essential to take care of sandy beaches. They are not only important for recreation, but also for conservation."

The study is said to be the first-ever quantification of earthquake and tsunami effects on sandy beach ecosystems along a tectonically active coastal zone. The paper can be found online at http://dx.plos.org/10.1371/journal.pone.0035348.

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† Top image: Damage and debris from the February 2010 earthquake and tsunami strewn across the revetment and uplifted beach at Llico.

Credit: Eduardo Jaramillo

†† Middle image: This March 2010 photograph of the beach at Punta Lavapie reveals the extent of the uplift — these former subtidal rocky bottoms were completely submerged in water — at all times — prior to the Maule earthquake and tsunami.

Credit: Eduardo Jaramillo

††† Bottom image: Eduardo Jaramillo and Jenifer Dugan revisited Lebu in April 2012, as they continue to study the recovery of Chile's sandy beaches from the 2010 earthquake and tsunami.

Credit: Carlos Sotomayor

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