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# Studying past sea level change is key to understanding ongoing and future sea level rise



**Sea levels are currently rising at an accelerating rate. Records of past sea level rise provide vital information that can inform projections of future sea level rise.**

Legends of sunken cities and empires, like Plato's Atlantis or Tolkien's Númenor in Middle Earth, have fascinated people for centuries, but not all stories of submerged civilizations are fictional. Humans famously crossed into the Americas via the Bering Land Bridge before it became submerged 11,000 years ago[1]. Sea levels continued to rise, and hunter-gatherers, who were living where the North Sea is today, were displaced when rapidly rising seas flooded the region 8000 years ago[2,3]. The threat of rising sea levels to coastal communities is not just in the past. Sea level rise has the potential to displace coastal communities and impact coastal ecosystems. Information about the processes that caused past sea level change is key to the improvement of projections of future sea level rise. The focus of this collection of articles from Nature Geoscience, Nature Communications, Communications Earth and Environment, and Scientific Reports is the current state of the science of past sea level change.

Sea levels have fluctuated radically over Earth's history. Global mean sea level was 5 to 10 m higher 129,000–116,000 years ago when the global mean surface temperature was +0.5 °C to +1.5 °C warmer than it was between 1850–1900[4]. Sea level rose at this time due to the expansion of warmer seawater and the melting of ice on the land that then flowed into the ocean. Conversely, sea level was 125–134 m lower than at present 21,000–19,000 years ago when the global mean surface temperature was 5 °C to 7 °C colder than the 1850–1900 level[4] because water was trapped in expansive ice sheets in the Northern Hemisphere.

We know that that sea level changed so dramatically during these early periods because these sea level changes are geologically imprinted on the Earth. Corals, sediment, ice, and other natural samples that show sea level change and its drivers are called proxy records. The accurate interpretation of these records is integral to understanding past sea level change. One of the most utilized regional sea level proxies is the location and age of fossilized corals because coral grows at different ocean depths depending on the species[5,6]. Other sea level proxies, like the oxygen isotopic content of the shells of fossilized single-celled marine organisms that are preserved in ocean sediments, are needed to fill in the time periods and geographic areas that corals are missing. These proxies in ocean sediments are used to reconstruct sea level because the oxygen isotopic content of the sea water when the organisms were alive depends on how much water was concurrently trapped as ice on the land[6]. Once regional sea level records are constructed using these and other proxies, they are combined to get a global picture of past sea level[6]. The combination of records is used to fill in gaps of time and regions that individual records cannot cover.

These compilations are then compared to earth system computer models of past sea level change. These models are developed to investigate the physical processes that resulted in past sea level variability[4,7,8]. Unfortunately, model results and proxy records do not always match-up[7–9]. This mismatch can be due to uncertainties in the proxy data or missing information about the physical processes that affect sea level used in the models.

There are several open research questions related to this mismatch between models and proxy records that require further investigation. For instance, sea level was higher 129,000–116,000 years ago, but the drivers of that sea level change, like ice sheet retreat, are still debated. A model that included both climate and ice sheet processes was used to determine that Antarctic ice was an important contributor to this sea level rise[7], but proxy records have yet to show this ice loss consistently[9]. The purpose of this collection of articles is to bring attention to studies that investigate these open questions.

We need to understand the past underlying mechanisms of sea level change so that we can improve forecasts of future sea level and mitigate its impacts. About 38% of the world's population is located in coastal regions[10]. Community displacement because of sea level

rise has already become a reality for many communities. Sea level will continue to rise at an accelerating rate due to climate change. We must understand past sea level change to know how to prepare for the future.

**"Sea level will continue to rise at an accelerating rate due to climate change. We must understand past sea level change to know how to prepare for the future."**

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