

Venice Holds Back the Sea



Just a few years ago, Venice, Italy, would flood more than 60 times a year. Until the Venetians decided to push back.

All that water was due to where Venice is built—in the middle of a lagoon. And why was it built there?

In the fifth century, Roman farmers, fleeing invaders, moved out to fishing huts on a string of low mud islands. Battered by tides, they built houses on stilts.

But their protection worked. While barbarians pillaged Italy, Venice thrived. Their settlement grew into a city, which grew into the greatest naval power in the Mediterranean—with the whole thing built on stilts.

Over the centuries, sediments beneath the city gradually compacted. The Venetians responded by jacking up their buildings farther.

But in the twentieth century, drilling and extraction of groundwater and natural gas caused the city to sink faster, while the Adriatic Sea level rose.

Tidal flooding became so frequent that Venice built a system of 79 enormous steel gates at the inlets to their lagoon. Each gate is 100 ft tall and weighs 300 tons. It rests flat on the seafloor—till an overly high tide is predicted.

Then, Venice pumps the gates full of air, and they slowly stand up, able to hold back 10 ft of ocean surge. When the threat is over, they sink back to the seafloor.

There are many other subsiding cities, like New Orleans, Miami, and Jakarta, keeping a watchful eye on the sea—and on the amazing gates of Venice.

Piazza San Marco during a typical *acqua alta* flooding event in Venice, Italy.

Credit: grumpyllumixer (CC BY 3.0 [<http://creativecommons.org/licenses/by/3.0/>]), via Wikimedia Commons



BUREAU OF
ECONOMIC
GEOLOGY

Background: Venice Holds Back the Sea

Synopsis: Venice—the city of water—grew to power over the centuries protected by the sea. But now the sea is encroaching on the self-proclaimed “floating city,” which is a UNESCO World Heritage Site. Subsidence, extreme weather, and sea-level rise have combined to threaten this vulnerable municipality, but its citizens are fighting back with an audacious plan.

- Venice dates back to the fifth century fall of the Roman Empire, when farmers from the mainland fled to nearby marshes and sandy islands of the Venetian lagoon to escape advancing barbarians.
 - The city originated as a group of small temporary fishing villages with houses built on stilts, but it eventually became a permanent settlement.
 - For centuries, the sea protected Venice from enemy invaders. The lagoon is protected by a 28-mile chain of barrier islands.
 - By the ninth century, Venice was an important fishing and business center, and the villages joined forces to create a single government with commerce and residences developing along the canals.
 - “The Most Serene Republic of Venice” was the trading capital of Europe and amassed vast riches and art through the Middle Ages and Renaissance.
 - The republic extended from eastern Italy to Croatia along the Adriatic Sea and established trading posts as far away as Greece and Turkey.
 - Venice became a formidable Mediterranean power and even captured Constantinople, the Byzantine capital, in 1204.
 - Declining in power after thirteen centuries, the city was captured by Napoleon when he invaded Italy in 1797.
- Venice is a masterpiece of ancient civil-engineering accomplishments.
 - Venice is built on a cluster of 118 muddy islands connected by more than 25 miles of canals and more than 400 bridges.
 - Its buildings were not built directly on the soft sediment of the islands; rather, they were built on wooden platforms supported by wooden pilings driven 15 ft into the lagoonal sediments. The wood does not decay because of the lack of oxygen in the sediments; it petrifies over time.
 - Freshwater collection systems were built into plazas throughout the city; water flowed from drains in the plaza through sand-filtering systems into central plaza wells. These collection systems operated into the late 1800’s, when an aqueduct from the mainland was constructed.
 - The canals of Venice are globally famous, as are their gondoliers, who steer hundreds of gondolas throughout the floating city. Venice is the largest car-free area in Europe; all travel occurs on foot or by boat.
 - The canals were built to enable efficient transportation but were also intended to control drainage and flooding. Still, the city floods regularly.
- Venice was built on the soft sediments of a lagoon that formed at the northern end of the Adriatic Sea, where five minor rivers drained from the Southern Alps and Northern Apennines.
 - Venice has been subsiding into the salt-marsh sediments as they slowly compacted, and centuries of dredging and human influence on the lagoon have taken their toll.
 - In the twentieth century, Venice subsided 9 inches. Wells drilled into freshwater aquifers below the lagoon increased the subsidence rate, so the practice was terminated.
 - Offshore gas drilling is thought to have also contributed to subsidence.

References: Venice Holds Back the Sea

- [History of the Republic of Venice | Wikipedia](#)
- [Lagoon of Venice Geological Setting, Evolution and Land Subsidence | Episodes Sept. 2003](#)
- [Venice’s Gradual Sinking Charted by Satellites | LiveScience](#)
- [Parting the Sea to Save Venice | NASA Earth Observatory](#)
- [What Is the World’s Most Vulnerable City? | The Guardian](#)
- [Why Cities Sink | The Economist](#)

Contributors: Juli Hennings, Harry Lynch



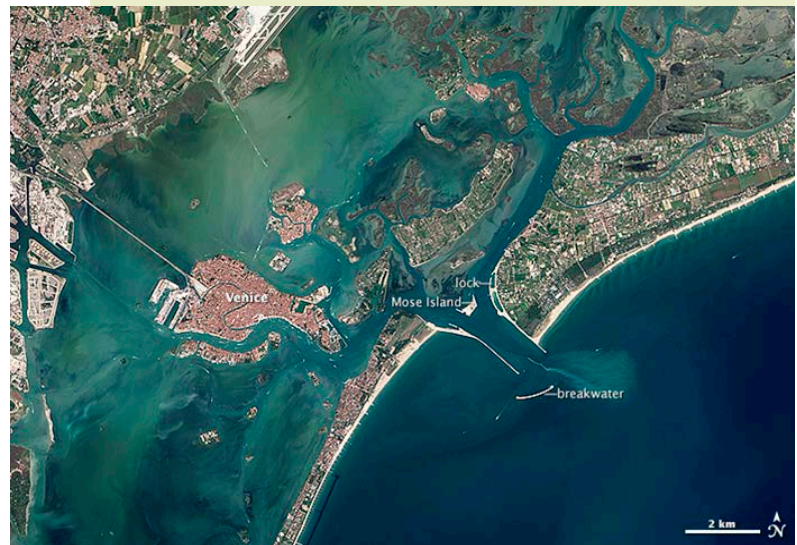
EarthDate.org
Fact Sheet:
Episode **ED 038**

Background: Venice Holds Back the Sea

- Modern satellite interferometry studies show that the city is still sinking, distinguishing between long-term natural subsidence of about 1 mm per year and short-term human-induced subsidence of up to 10 mm (0.4 inches) per year. The good news is that the human activities, like building, tend to result in localized short-term effects.
- Many other large cities are sinking because of natural subsidence of their deltas; subsidence related to loading of the ground by the weight of tall buildings; redirection of the natural processes of waterways; and groundwater, oil, or gas extraction. New Orleans, Miami, Jakarta, and Bangkok are some of the cities most impacted.
- In addition to subsidence, the level of the northern Adriatic Sea is rising about 1 mm per year; the lagoon that saved Venetians from conquest for centuries is now threatening the city.
 - Frequency of flooding has increased from 10 times per year in 1900 to more than 60 times per year at present—a testament to the city’s extreme sensitivity to sea level.
 - Known as *acqua alta* (high water), the floods are typically produced by unusually high tides enhanced by strong winds and storm surges, or by severe inland rains.
 - A freak 76-inch tide event in 1966 that destroyed millions of dollars of artwork, homes, and businesses led to serious research into ways to defend the city against the sea.
- The city has been fighting back against the elements with the MOSE (Modulo Sperimentale Elettromeccanico, or Experimental Electromechanical Module) Project, which began construction in 2003 and is expected to be operational by 2018.
 - MOSE is a series of 79 movable steel gates across the three ocean inlets to the lagoon that would block up to 3 m (118 inches) of tides during extreme events.
 - Each gate is 98 ft high, 65 ft wide, 16 ft thick, and weighs 300 tons.
 - The gates remain hinged flat on the seabed in normal weather, but if high tides are predicted, compressed air is pumped into them; in about an hour they pivot upward to separate the lagoon from the sea. After the event, the gates are filled with water and drop back to the seabed.
 - The acronym *MOSE* is no accident—just as Moses parted the Red Sea, Venetians are betting that the MOSE gates separate the Venetian Lagoon from the Adriatic Sea when the city is threatened.

Venice, the “floating city,” in the middle of the Venetian Lagoon with protective MOSE structures in place in the Lido inlet, September 4, 2013.

Credit: NASA Earth Observatory



References: Venice Holds Back the Sea

- [History of the Republic of Venice | Wikipedia](#)
- [Lagoon of Venice Geological Setting, Evolution and Land Subsidence | Episodes Sept. 2003](#)
- [Venice’s Gradual Sinking Charted by Satellites | LiveScience](#)
- [Parting the Sea to Save Venice | NASA Earth Observatory](#)
- [What Is the World’s Most Vulnerable City? | The Guardian](#)
- [Why Cities Sink | The Economist](#)

Contributors: Juli Hennings, Harry Lynch