A rogue wave caused a cruise ship tragedy. They occur more often than you think.

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A possible rogue wave sent headlines around the world last week after it broke windows on a cruise ship off the coast of Argentina, killing a woman and injuring four others.

Such freak accidents may seem rare, but hundreds have occurred without warning around the world—on cruise ships, cargo vessels, oil

platforms and beaches.

Observers often describe them as a "wall of water," but the size of that wall is relative depending on whether you're in a fishing boat or a cargo ship.

The six deck Viking Polaris was sailing back toward Argentina after a trip to Antarctica on Nov. 29 when a massive freak wave struck the ship. Viking Cruises called it a "rogue wave" but researchers said only further investigation will verify if it truly met the definition—more than twice as high as the average of the highest surrounding waves.

Monstrous and deadly waves that arrived without warning have been recounted in fishing and sailing lore for more than a century. More modern records show how often they truly occur: Some 432 similar incidents were documented internationally between 2005 and 2021 in a catalog kept on the Russian Academy of Science's Institute of Applied Physics website.

Here's what to know about rogue waves.

What is a rogue wave?

Rogue waves are driven by wind. They form when waves coming from multiple directions meet at one point by chance, said Francesco Fedele, an associate professor at Georgia Tech. "It's the constructive interference of waves coming from multiple directions. They all pile up and form this extreme event."

They sometimes occur when waves move into strong opposing currents, such as in the Gulf Stream in the North Atlantic and off the coast of South Africa, according to the National Oceanographic and Atmospheric Administration. It can be a single wave, or a series of three or four.

It's often impossible to know if monster waves are an actual rogue wave.

A rogue wave is defined as 2.2 times higher than the waves around it, said Johannes Gemmrich, a physical oceanographer at the University of Victoria in British Columbia. The waves are measured relative to "significant wave height," determined by averaging the highest one-third of waves.

If the significant wave height is 6 feet, a rogue wave would have to be 13.2 feet. Some freakishly high waves that cause maritime disasters may be enormous, but may only be 1.9 times as high as the surrounding seas, Gemmrich said. "Unless you have measurements for an individual wave, you can't tell if it was some rogue wave."

What happened on the Viking Polaris?

The Polaris was in the Drake Passage, treacherous waters known for rough seas and big waves. Called the "Drake Shake" or the "Drake Lake" depending on the height of the seas, it's where the waters of the Atlantic and Pacific oceans come together between the southern tip of Argentina and Antarctica.

California sailing enthusiast Ken Spencer was a passenger on deck two, an estimated 25 feet above the water line. He told U.S. TODAY that waves of 20 to 25 feet were consistent in frequency and direction during the day and then turned less so into the evening, coming from mixed directions.

As he was preparing for bed, Spencer said, "this wave came directly broadside at the port side," not from an angle like the previous waves.

"The wave had tremendous volume, and it seems to have risen as high at deck four, which is about 45 feet above the waterline," he said. "The

thickness of the wave is what was amazing. The water stayed against my window for what seemed like seconds, but was likely around a second."

At the same time, the Polaris was jolted with a very powerful bump, he said.

Photos of the vessel show windows were broken in several staterooms and several rooms were breached by water. His window was intact but a few gallons of water had seeped in around the perimeter, said Spencer, who praised Viking and the vessel's crew.

How often do rogue waves occur?

Much more often than many realize.

Gemmrich estimates waves up to twice as high as the surrounding wave heights occur about every 3,000 waves and that a rogue wave may occur every 15,000 waves.

"The higher the relative wave heights increase, the more unreal the rogue waves become," Gemmrich said. "A wave three times higher than the background, that's extremely rare."

It's those monster waves that occur when the background waves are 30 to 40 feet high that concern the shipping industry.

What's the difference between a rogue wave and a tsunami?

- A tsunami is a very long wave of seismic origin, generated by earthquakes, volcanoes and landslides. In the open ocean tsunamis have small wave heights, but in shallow water closer to

the coast wave height can increase to 30-60 feet.
- Rogue waves are generated by wind and are shorter waves. Although they often occur in the open ocean, and during stormy conditions, they also occur in coastal waters.
- Meteotsunamis are typically waves smaller than tsunamis caused by air pressure disturbances in fast moving storms.

Is climate change to blame?

Some research has suggested warming temperatures are contributing to higher waves and more extreme wave heights in some regions.

The Intergovernmental Panel on Climate Change concluded with "high confidence" last year that significant wave heights are projected to increase across the Southern Ocean and tropical eastern Pacific and decrease over much of the Atlantic and the Mediterranean Sea.

However, in the North Atlantic, the panel found low confidence in projected changes in extreme wave conditions "due to limited evidence" and medium confidence that wave heights already have increased above 45 degrees latitude. Wave heights are projected to increase in the Arctic Ocean because of a reduction in sea ice.

Gemmrich said it's more likely that locations could change where rogue waves occur more often, because of shifts in storm tracks.

A lot is still unknown about rogue waves

There's still a lot to learn about rogue waves, in part because they've only been confirmed by instruments within the last 30 years. The first technical confirmation of a rogue wave took place in 1995 during a New Year's Day storm.

An extremely large wave hit the Draupner Oil rig platform off Norway in the North Sea. The crew didn't realize they had been hit by a rogue wave until they discovered scaffolding erected under the deck for repairs had been washed away. A laser sensor recorded the 85-foot wave, about the height of a 10-story building.

Today, satellites, radars and ocean floor sensors all help collect crucial data, but because the waves are unpredictable they're difficult to study.

Gemmrich recently concluded that the most extreme rogue wave ever recorded took place off Vancouver Island, British Columbia in November 2020. Gemmrich and a student at the University of Victoria, Leah Cicon, analyzed buoy data and found the crest measured 57.7 feet high, compared to the surrounding waves averaging 19.6 feet, nearly three times as high.

Researchers are particularly interested in solving the mysteries surrounding rogue waves, hoping to be able to provide early warnings so that shipping companies could avoid areas where dangerous conditions increase the risk.

The European Space Agency concluded in 2004 that rogue waves had sunk more than 200 vessels over the previous 20 years.

Infamous incidents likely caused by freak or rogue waves

Among the rogue wave stories recounted by mariners are two maritime disasters memorialized in film and song:

►The George Clooney thriller, "A Perfect Storm," was based on the disappearance of the fishing vessel Andrea Gail during a nor'easter that

absorbed a hurricane off Nova Scotia in 1991. Six men were lost. Canadian officials reported buoys in the area recorded peak waves in excess of 60 feet.

►The 1975 Gordon Lightfoot ballad "The Wreck of the Edmund Fitzgerald" was written after the freighter sank without a distress signal in Lake Superior during a gale on Nov. 10, 1975, killing 29 crew members.

►In 1942, the Queen Mary was hit by a 75-foot wall of water as it was taking 15,000 U.S. troops to England during World War II. It was one of at least five similar incidents along the route between 1924 and 1966.

►In August 1905, 20 of 22 crew members perished when the steamer Peconic went down off the Georgia coast.

►One hundred years later, the Norwegian Dawn cruise ship, with 3,700 passengers and crew, was headed for New York when it was hit by a series of three waves, with at least one estimated at 69 feet, during a storm off the Georgia/South Carolina coast. The force of the water sheared off aluminum rail supports and sent teak balcony railings and water through the windows of two cabins on decks nine and 10. The ship diverted course to South Carolina and the captain told people he'd never seen anything like it.

►On July 3, 1992, a wave then estimated at a height of 18 feet, struck Daytona Beach around 10:30 p.m., injuring 20 and tossing cars around. One vacationer described it as a "huge wall of white water."