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The Real Sea Monsters: On the Hunt for Rogue Waves

Scientists hope a better understanding of when, where and how mammoth oceanic waves form can someday help ships steer clear of danger

By Lynne Peeples | Wednesday, September 2, 2009 | 10

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BIG, BAD WAVE: A monster rogue wave approaches a merchant ship in the Bay of Biscay, an arm of the Atlantic Ocean bordered by the coasts of northwestern Spain and southwestern France. Image: NOAA'S NATIONAL WEATHER SERVICE COLLECTION

A near-vertical wall of water in what had been an otherwise placid sea shocked all on board the ocean liner *Teutonic*—including the crew—on that Sunday in February, more than a century ago.

"It was about 9 o'clock, and [First Officer Bartlett], as he walked the bridge, had not the slightest premonition of the impending danger. The wave came over the bow from nobody seems to know where, and broke in all its fury," reported *The New York Times* on March 1, 1901: "Many of the passengers were inclined to believe that the wave was the result of volcanic phenomena, or a tidal wave. These opinions were the exception, however, for had the sea been of the tidal order Bartlett would have seen it coming." The volcano theory was just as unlikely: "Absurd, absurd," one of the Teutonic's officers told the *Times*. "It was a giant sea, and there is no doubt of that."

This is just one of the many anecdotal accounts in maritime history of waves upward of 30 meters devouring ships, even swallowing low-flying helicopters. But what sea captains and scientists have long believed to be true only gained widespread acceptance after the first digitally recorded rogue wave struck an oil rig in 1995. "The seamen tales about large waves eating their ships are correct," says Tim Janssen, an oceanographer at San Francisco State University. "This was proof to everybody else, and a treat for scientists. They suspected it, but to see it and have an observation is something else."

Now that there is no longer a question of rogue waves' existence, other mysteries have arisen: How frequently do they occur? Just how do they come about? Are there areas or conditions where they are more likely? Janssen is among a growing group of researchers in search of answers to these questions, which could someday lead to safer seas.

Rogue waves by the numbers

Before any answers could be attempted, scientists first had to characterize a rogue (or freak) wave. The widely accepted definition, according to Janssen, is a wave roughly three times the average height of its neighbors. This is a somewhat arbitrary cutoff. Really, he notes, they are just "unexpectedly large waves." The wave that swept onlookers off the coast in Acadia National Park in Maine on August 23 may not fit the former definition, for example, because background waves were already quite large due to Hurricane Bill, and rogues typically occur in the open ocean. Yet that wave has still been readily referred to as a "rogue".

No one is certain yet just how frequently freak waves form; accurate numbers are extremely difficult to collect given the waves' rare and transient nature. With more sophisticated monitoring and modeling—and as first-hand accounts are taken more seriously—the waves' prevalence appears to be rising. "[Rogue waves] are all short-lived, and because ships are not everywhere, the probability that a ship encounters one is relatively small," says Daniel Solli, who studies the optical version of rogue waves at the University of California, Los Angeles. "But with increasing amounts of oceanic traffic in the future, the likelihood of encountering them is getting larger."

Some areas seem to breed the waves more than others. Janssen and his colleagues recently used computer models to determine that regions where wave energy is strongly focused could be up to 10 times more likely to generate a freak wave. He speculates that approximately three of every 10,000 waves on the oceans achieve rogue status, yet in certain spots—like coastal inlets and river mouths—these extreme waves can make up three out of every 1,000 waves. A paper describing these results was published last month in the *Journal of Physical Oceanography*.

Forming fearsome waves

Various theories exist for how rogue waves form. The simplest suggests that small waves coalesce into much larger ones in an accumulative fashion—a faster one-meter wave catches up with a slower two-meter wave adding up to a three-meter wave, for example. Janssen and his colleagues build on this with a more complex, nonlinear model in their recent paper. Waves might actually "communicate—sometimes in a bad way—and produce more constructive interferences," Janssen explains. By communicating, he means exchanging energy. And because the conversations aren't necessarily balanced, he says, "Communication can get amplified enough that a high-intensity large wave develops." In other words, one burgeoning wave can actually soak up the energy of surrounding waves.

Again, in those places where variations in water depths and currents focus wave energies, this line of communication can get especially busy. Janssen's models identified these rogue-prone zones. Certain conditions such as winds and wave dissipation, however, could not be included, limiting the simulation's predictive power.

Meanwhile, Chin Wu, an environmental engineer at the University of Wisconsin–Madison sees another likely scenario spurring the monster waves: "If a wave propagates from east to west, and the current moves west to east, then a wave starts to build up," says Wu, who studies wave–current interactions in a 15-meter pool. The wave basically climbs the current's wall, rising out of what appears to be nowhere. Rogue waves have in fact been more common in regions such as the east coast of South Africa where surface waves meet currents running in the opposite direction.

Focusing on forecasts

The only way to really know what is going on in the unpredictable oceans is to watch, Wu says. He acknowledges, however, that the investments in the instruments and time necessary for such fieldwork are immense. "We need to identify places where [rogue waves] are more likely to occur," he says, emphasizing the importance of numerical models—including the nontrivial accounting of wind and wave breaking—at this step, "and then focus on those areas."

Focusing on an optical wave analogue may actually help scientists limit where they need to look. Light waves travel in optical fibers similarly to water waves traveling in the open ocean. "In optics we're dealing with a similar phenomenon, but doing experiments on the tabletop and acquiring data in only a fraction of a second," says U.C. Los Angeles's Solli. Although he doesn't suggest that optical experiments should replace ocean research, he suggests it could be a guide. Mapping light-wave conditions to the ocean could uncover parallel parameters that give rise to water waves. "Instead of looking for a needle in a haystack in the water, you could benefit from some beginning wisdom and narrow down the range," adds Solli, who co-authored a paper on optical rogue waves in the December 2007 edition of *Nature*. (*Scientific American* is part of the Nature Publishing Group.)

Janssen agrees with the need for more direct observations of ocean behavior. "We can make a theoretical prediction," he says. "But then we have to go out and see if nature agrees." If it does, the results "could provide a prediction scenario—made visible on maps—of hot spots that could change day to day," Janssen says. This could work much like tornado forecasting.

Only two passengers were seriously hurt in the *Teutonic* incident—one suffered a broken jaw and the other a severed foot. They were fortunate. "Had it struck us later on in the day many passengers would have been promenading in the sunshine, without doubt," Officer Bartlett told the *Times*. "There is no telling how many of them would have been injured." Extreme waves do not always offer such merciful timing, however. Forecasts could be crucial in helping future ocean liners evade the voracious sea monsters.