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Freak waves

A vessel is lost at sea every week. Two hundred of those lost in the past 20 years have been over 200 meters long. Unlike heavily investigated airplane crashes, there is often little information on the losses. Although human error and poor maintenance are frequently blamed, freak waves may have sunk many.

What are they?

Freak, or 'rogue', waves are exceptionally tall and abnormally shaped waves. They are steep mountains of water up to 30 meters high – the height of a 12-storey building. Although many freak waves occur in bad weather or near the coast, they can also appear in mid-ocean without warning in good weather. Freak waves are not tsunamis, which are caused by violent underwater disturbances and cause mainly coastal damage, as we have so tragically seen recently.

Examples

In February 1995, the *Queen Elizabeth II*, encountered a 29-meter high freak wave during bad weather in the North Atlantic. The Master said it "came out of the darkness" and looked like the "White Cliffs of Dover".

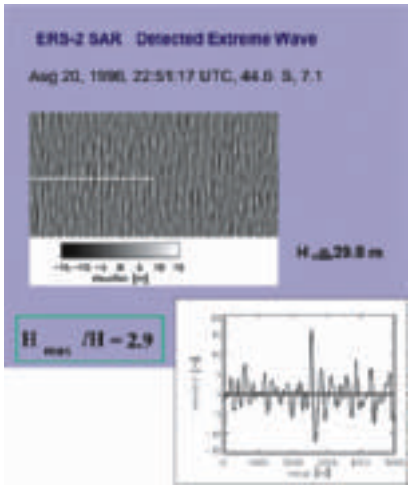
In February and March 2001, the *Bremen* and *Caledonian Star* were each rocked by 30-meter freak waves in the South Atlantic. The *Bremen* was left without navigation or propulsion for two hours. The First Officer of the *Caledonian Star*, which was 'blinded' when all of its instrumentation was lost, noted that the wave was "just like a mountain, a wall of water coming against us".

On New Year's Day 1995, the *Draupner* oil rig was in the middle of a storm in the North Sea. Its radar sensors were regularly recording waves with heights of 12 meters, when it was suddenly hit by a freak wave 26 meters high.

Do they really exist?

Since ships first sailed the oceans, mariners have spoken of "holes in the sea" and monstrous waves. Such tales have largely been dismissed as folklore. The *Draupner* wave attracted serious attention, however, as it had been measured by the oil rig's sensors. A wave of 26 meters in a background sea state of 12 meters was simply not supposed to happen.

Until recently, scientists thought that all waves conformed to the Linear Model, which sets out a bell-shaped graph of the probabilities of certain wave heights. According to this theory, a 30-meter wave should occur in a 12-meter sea state once in every 10,000 years. The *Draupner* wave therefore called into question the validity of the Linear Model.



Proof is in the data – evidence of an extreme wave in August 1996

The European Union started a freak wave project called MaxWave in 2000. It is significant because it analyses satellite data covering the world's oceans, including 'raw imagettes' with a resolution of ten meters. MaxWave analysed satellite data for a three-week period in 2001 and identified more than ten individual freak waves around the

Photo: Scanpix/Corbis

Danger offshore – as opposed to a normal 12-meter wave with a force of 6MT/m², a breaking freak wave reaches a force of around 100MT/m²

world that were greater than 25 meters in height. This was a shocking revelation. It showed that freak waves are real and much more common than expected.

What causes freak waves?
Nobody knows yet. There may be multiple causes. It is generally accepted that some exceptional currents create freak waves. When waves head directly against a strong current, the current can drive the waves up unusually high and steep. The most famous of these is the Agulhas Current off the East Coast of South Africa, which produces waves 20 meters high. Since 1990, these waves have destroyed twenty ships. Fortunately, freak waves of the Agulhas Current are often predictable and local authorities even provide wave warnings. As a result, mariners can take appropriate action.

There are other areas in the world that have a particular tendency to be exposed to freak waves, including the seas off Norway, the Gulf Stream, the Kuroshio current, the Nantucket Shoals and Cape Horn.

Unfortunately, satellite research shows that freak waves also occur in high seas in areas that are not affected by known currents or geographical formations. Such 'random' freak waves are more problematic because they are unpredictable.

Wave mathematicians are looking to the non-linear realm of quantum mechanics for a new theory to understand such

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unpredictable freak waves. It may be that some waves 'steal' energy from neighboring waves to grow into large, unstable waves, characterized by 'holes in the sea' and steep 'breaking' waves. Instead of breaking on sand, however, rogue waves at sea can break on a vessel that has just fallen into the wave's 'hole', or trough.

How strong are they?
The force of a breaking freak wave is tremendous. A 12-meter wave in the Linear Model has the force of about 6 MT/m². A rogue wave, however, has a force of about 100 MT/m². Modern day vessels are designed to withstand only 15 MT/m². It is therefore understandable why some ships do not survive freak waves.

Further research
MaxWave has embarked on an ambitious program to learn more about freak waves, including assessing the risk of a vessel encountering a freak wave, how to recognize freak waves and how to determine their regional probability of occurrence. Although many freak waves appear to occur randomly, there may be a deeper mechanism at work that could give a method of predicting their occurrence or indicate which regions are most at risk. MaxWave also hopes to apply new knowledge to improve ship design.

What can mariners do now?
Current research may be of little comfort to crewmembers in danger of encountering freak waves now. Fortunately, there are some things that mariners can do immediately.

First, they should be aware of those areas that are already known to have a higher risk of freak waves.

Second, mariners should be aware that the following sea conditions may create freak waves (by themselves or together): (1) low pressure systems, (2) wind blowing in one direction for more than 12 hours, (3) waves traveling at the same speed as a moving weather system, (4) waves going against a strong current, (5) fast waves catching a set of slower moving waves and merging into a single rogue wave.

Freak waves caused by the above are at least somewhat 'predictable'. The most dangerous freak waves are those that cannot be predicted and do not emerge out of a known set of factors likely to create large waves. Here, an alert watch by the crew could save the vessel. In many of the cases in which a vessel has survived a rogue wave encounter, the

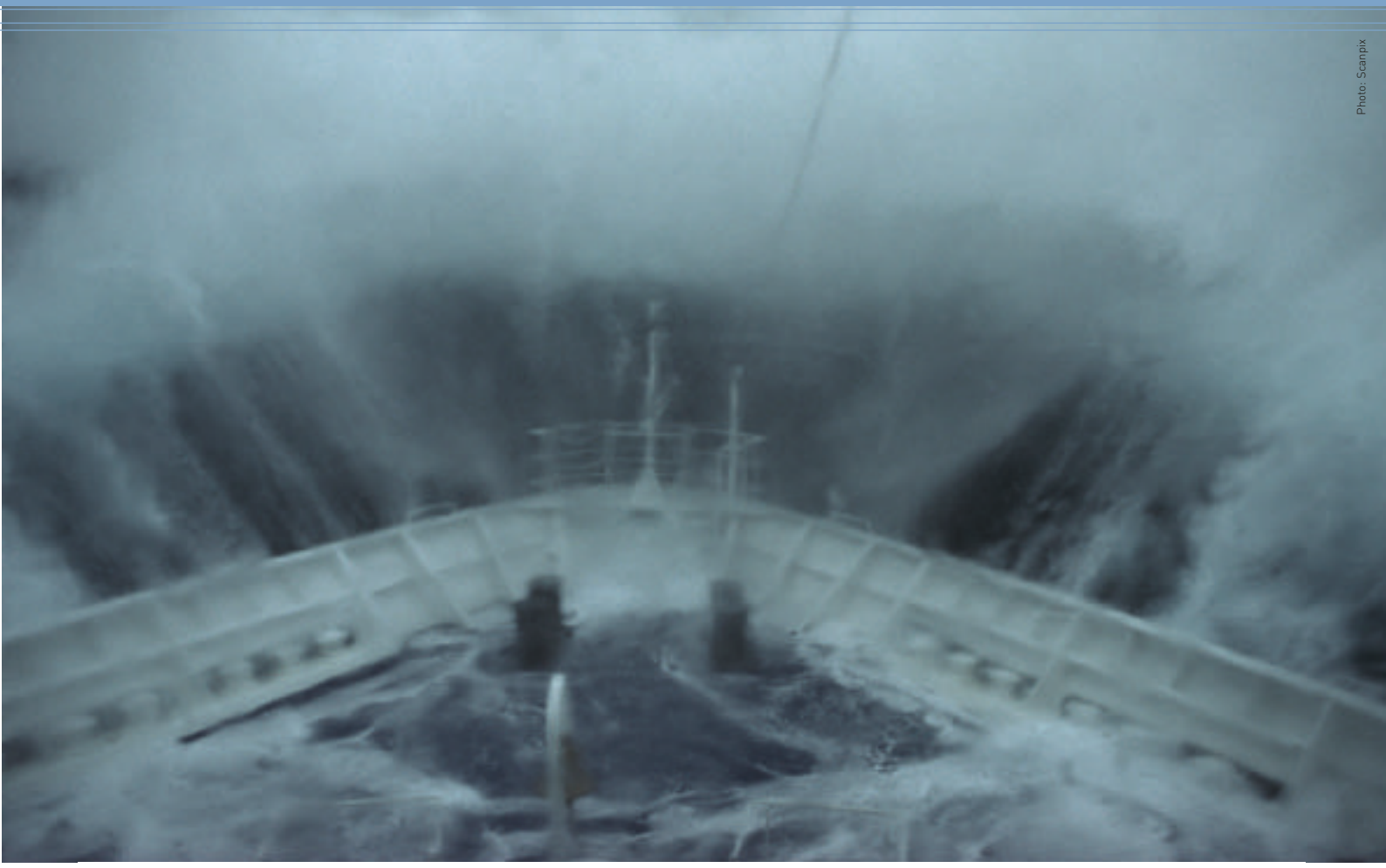

Photo: Scanpix

The most dangerous freak waves do not follow any known model

wave was spotted just in time for the vessel to take at least some action to limit the wave's destructive effect.

Further, vessels should be well-equipped with safety equipment, such as life rafts, life vests and cold weather gear, if appropriate. Crews should be well trained to handle a vessel in distress. Finally, owners and crewmembers should monitor the on-going research on rogue waves. MaxWave hopes to eventually publish a 'wave atlas' of rogue wave events and analyses, which could be invaluable to mariners.

See the MaxWave website at http://www3g.gkss.de/projects/maxwave.

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