Rough math: Focusing on rogue waves at sea

In late 1942, carrying 15,000 U.S. soldiers bound for England, the *Queen Mary* hit a storm about 700 miles off the coast of Scotland. Without warning amid the tumult, a single, mountainous wave struck the ocean liner, rolling it over and washing water across its upper decks. Luckily, the ship managed to right itself and continue on its voyage.

Gargantuan waves, which appear unexpectedly even under calm conditions in the open ocean, have damaged and sunk numerous ships over the years. Now, researchers have identified a plausible mechanism that may account for the occurrence of these rogue waves. Using a mathematical model, they demonstrate that ocean currents or large fields of random eddies and vortices can sporadically concentrate a steady ocean swell to create unusually large waves.

The current or eddy field acts like an optical lens to focus the wave action, says applied mathematician Bengt Fornberg of the University of Colorado at Boulder.

Fornberg and Benjamin S. White of Exxon Research and Engineering Co. in Annandale, N.J., describe their model in a report submitted to the JOURNAL OF FLUID MECHANICS.

Rogue waves can arise in all oceans. However, their frequency and size are particularly notable off the southeastern coast of South Africa. Every year, a few supertankers and other major vessels suffer severe structural damage while traveling southward along a standard route from the Middle East to the United States or Europe.

The vessels boost their speed by taking advantage of the strong, south-flowing Agulhas Current, which skirts the South African continental shelf. Depending on the prevailing winds, this current often meets a steady incoming wave swell nearly head-on. The interaction of wave and current reduces the spacing between the waves and changes their direction.

Applied mathematician Marius Gerber of Stellenbosch University in South Africa recently showed that changes in wave direction forced by a narrow, fast current can raise wave heights considerably in certain areas of the current. His calculations also suggest that such waves would have a distinctive shape, displaying a steep forward face preceded by a deep trough. Mariners who have experienced rogue waves have described such troughs as "holes in the sea."

This focusing mechanism is very likely responsible for the freak, isolated waves encountered in the Agulhas Current, Gerber argues. Such focusing could also occur within or near the Gulf Stream in the North Atlantic.

Fornberg and White have now shown, in principle, that similar focusing can take place when an ocean swell of regularly spaced waves traverses an area of random current fluctuations. They can compute the probability of particularly intense wave action and the formation of rogue waves in different regions of the field. These probabilities depend on how far the waves of the ocean swell have traveled through the eddies rather than on the detailed structure of the eddies themselves.

Exploratory work on the formation of rogue waves at sea and in currents has been largely theoretical so far. The chief problem is the extreme shortage of reliable, complete oceanographic data on this phenomenon to test the mathematical models.

The waves arise rarely, although they're very notable when encountered, Fornberg notes.

The ultimate goal of the researchers is to develop models to predict the location of danger areas and to forecast the occurrence of rogue waves, which would allow ships to proceed safely yet take advantage of ocean currents.

The Agulhas Current is a prime target for such an effort. The latest incident in the area occurred earlier this month, when a cargo ship with 29 people aboard sank after being hit by a wave, presumably a freak giant. —*I. Peterson*

Eyeing fetal cells to reverse blindness

Testing an experimental treatment that they liken to replacing old, deteriorated film in a camera with a fresh roll, scientists have begun injecting cells harvested from the eyes of aborted fetuses into the eyes of people with retinitis pigmentosa, the most common inherited cause of blindness.

This week, researchers involved in the effort claimed that five of the first eight patients who received the fetal cells have experienced discernible, though extremely limited, improvement in vision.

Such cell transplants are unlikely ever to restore completely the eyesight of people with retinitis pigmentosa, but even a small improvement in vision would be welcome and useful, says Manuel del Cerro of the University of Rochester (N.Y.) School of Medicine and Dentistry, who reported the initial results of the cell transplants at a Society for Neuroscience meeting in Washington, D.C.

Retinitis pigmentosa, which afflicts several million people worldwide, slowly robs a person of sight by destroying the photoreceptor cells that line the eye's retina. The light-sensitive cells, commonly known as rods and cones, convert incoming images into patterns of electric impulses that travel through other retinal cell layers and finally to the brain.

For more than a decade, del Cerro and other researchers have investigated whether rods and cones ravaged by retinitis pigmentosa could be replaced with new photoreceptors (SN: 11/4/89, p. 297). In 1991, del Cerro's group found that fetal eye cells implanted into the eyes of blinded rats partially restored the animals' ability to perceive light (SN: 11/23/91, p. 325).

Those results encouraged del Cerro to collaborate with eye surgeons at the L.V. Prasad Eye Institute in Hyderabad, India, on a human trial. The surgeons selected eight retinitis pigmentosa patients whose vision had deteriorated to the point where they could only perceive the difference between light and dark. Working on one eye of each patient, the surgeons made a small incision in the retina and injected about 1 million fetal eye cells into the space beneath the incision.

Their hope was that the fetal eye cells, which had yet to differentiate into any one cell type, would develop predominantly into new photoreceptors and establish the retinal connections needed to convey visual information.

It took 4 to 6 months before any of the patients reported an improvement in vision, says del Cerro. Two of the patients now detect hand motion, he says. Two others can reportedly count fingers held up at a short distance.

The fifth patient can now recognize faces and walk around unaided, thanks to the development of a tiny field of view in which he has 20/200 vision. It's "a little keyhole view of the world," says del Cerro.

Several retinal transplant researchers contacted by SCIENCE NEWS argue that the trial in India should have included an independent evaluation of each patient's vision before and after the surgery.

"I simply don't believe these results," says Peter Gouras of Columbia University, who has experimented with cell transplants for a retinal disease called age-related macular degeneration.

Other vision researchers privately echo Gouras' skepticism, and some raise the issue of whether there has been sufficient evidence that cell transplants work in animals to justify the decision to start trials in humans.

Undeterred by the criticism and buoyed by the apparent success of the first trial, del Cerro and his colleagues have already started additional human trials in India and at Johns Hopkins Medical Institutions in Baltimore. A research group led by Henry Kaplan of Washington University in St. Louis is ready to start its own human trial of the cell transplant strategy, using photoreceptors harvested from adult eyes. —*J. Travis*