Ripple Marks
The Story Behind the Story

BY CHERYL LYN DYBAS

LAID BARE

SEAFLOOR IN SOUTH PACIFIC OCEAN DEVOID OF SEDIMENT. A bare zone at the bottom of the central South Pacific Ocean is completely devoid of sediment, marine geologist David Rea of the University of Michigan has discovered. It's the only seafloor beneath the world's oceans without sediment deposits.

This broad region of ocean bottom is nearly the size of the Mediterranean Sea. It has been swept clean of sediment since the Late Cretaceous, Rea believes. He and colleagues published their findings in the October 2006 issue of the journal *Geology*.

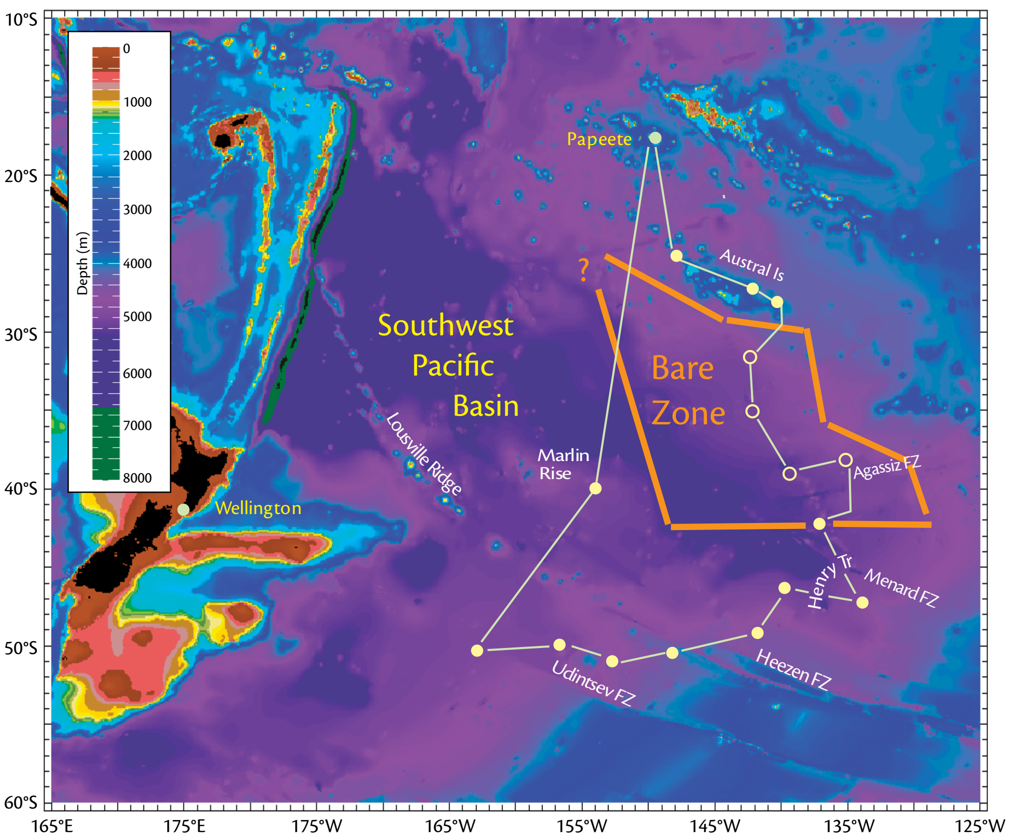
"A combination of very low biological productivity, a shallow calcite compensation depth [the depth at which the remains of carbonate-secreting plankton are completely dissolved], essentially no dust blowing off landmasses, and no deposition from hydrothermal vents is likely responsible," says Rea. "One or two of these conditions are common in the oceans, but nowhere else on Earth do all four occur."

In February and March 2005, geologists aboard R/V *Melville* surveyed and drilled cores from several sites in the southwest Pacific Basin. "Before this expedition, there wasn't much information about this remote area of the ocean," says Rea. "Some features there had been well-surveyed in the past, such as parts of the Heezen-Tharp fracture zone and the Louisville Seamount chain, but most were unknown."

Several cores were retrieved from depths ranging from 4,000 to 5,300 meters. "Material in these cores will go far toward advancing our understanding of the paleoceanography and paleoclimatology of this remote part of the world," Rea believes.

But the most intriguing result, he says, was finding the bare zone, whose boundaries, the scientists write in *Geology*, "comprise a vast area of the central South Pacific Ocean."

The South Pacific bare zone may be the only place in the world where rock on the ocean bottom has been exposed directly to seawater—for more than 80 million years.



Map of the Southwest Pacific Basin showing the large "bare zone." Open circles are sampling locations that were sediment-free; closed circles are stations that brought back sediment. *Figure modified from Rea et al.,* Geology, *34(October):873–876*

FULL MOON AS EARTHQUAKE TRIGGER?

Photo credit: NASA/JPL-Caltech

IT HAPPENS ONCE IN A BLUE MOON, THE SAYING GOES. Legend holds that blue moons—the second full moon in one month—are harbingers of unusual occurrences. In 2007, June has a blue moon: a full moon on June 1st and another on June 30th.

Could a full moon, blue or otherwise, in fact be a trigger for rare events on Earth?

For centuries, scientists have known that ocean tides are driven by the pull of the moon. But researcher Robin Crockett of the UK's University of Northampton believes that full moons are responsible for more than very high and low tides. "A full moon may have triggered the earthquake that caused the devastating tsunami on December 26, 2004," says Crockett. He and colleagues found that major earthquakes are 86 percent more likely around full (and new) moons, when tides are at their highest and lowest. They published results of their research in the October 5, 2006, online edition of the journal *Geophysical Research Letters*.

"At full and new moons, a big mass of water is being loaded and unloaded at the plate boundary in the Indian Ocean," Crockett says. "That might be the proverbial 'straw that broke the camel's back,' and triggered an earthquake."

Between October 2004 and August 2005, Crockett monitored tremors and amassed tidal data along the Java/Sumatra trench.

"During this period, variations in earthquake activity correlated with tidal-force cycles," he says. "Maximum earthquake activity occurred at full and new moons, typically lagging by no more than three days—and sometimes on the day of a full moon."

Tidal force has two influences on Earth's crust: direct tidal attraction, the force between the rocks in the crust and the moon (solid Earth tides); and ocean tidal loading, the movement of water that cyclically loads and unloads force onto regions of Earth's crust.

"In either case, or in the case of a combination of the two influences, the net effect is that Earth's crust is cyclically stretched and compressed," says Crockett. "There are also longer-period cycles in tidal force, a result of varying orbital relationships between the three solar-system bodies involved: Sun, Earth, and Moon. Local/regional variations in tides also play a part, depending on the configuration of the coast in a certain area."

The subduction zone where the December 26, 2004, event took place is subject to asymmetric tidal loading: the tectonic plate on one side is covered by the Indian Ocean; the other side is made up of landmasses, including the Indonesian Islands and shallower seas.

"Consequently the descending Indian plate may be subject to greater tidal loading than the Asian plate," says Crockett. "We think this causes the crust to flex in a hinge-like manner at this complex plate boundary." The lag is different between the two sides, suggesting that cyclical crustal flexing, at a maximum during full or new moons, might provide enough extra force to trigger an earthquake at a plate-boundary region already on the point of rupture. "The 2004 Sumatran earthquake was just waiting to happen, perhaps for a full moon," says Crockett.

If he's right, ancient wisdom about the strange effects of the full moon may find its place in today's scientific studies.

The last full moon of 2004 occurred on none other than December 26th.

Photo credit: Seawatch.org

STARS UNDER THE SEA

WHAT DO AN ASTROPHYSICIST, A MARINE BIOLOGIST, AND A COMPUTER PROGRAMMER HAVE IN COMMON PROFESSIONALLY? If they're Zaven Arzoumanian, Brad Norman, and Jason Holmberg, respectively, they're using pattern-matching tools from astronomy to further whale shark conservation.

Arzoumanian, an astrophysicist at NASA Goddard Space Flight Center in Greenbelt, Maryland, usually works on deciphering x-rays and radio waves emitted by neutron stars and black holes. Norman studies whale sharks (*Rhincodon typus*), the world's largest fish, as they migrate to and from their breeding grounds. Along with Holmberg, Arzoumanian and Norman used a computer algorithm to transmute patterns in the stars into a marine species management tool designed to better understand whale shark biology.

"Whale sharks are the world's largest fish species, but they're rare and poorly studied," says Norman. Whale sharks have a broad distribution in tropical and warm temperate seas between latitudes 30°N and 35°S. The World Conservation Union (IUCN) *Red List of Threatened Species* lists whale sharks as vulnerable to extinction as a result of their highly migratory nature, low abundance, value in international fisheries, and slow reproduction rates.

Whale sharks are born with unique body pigmentation, says Norman, that's retained throughout their lives. "This natural patterning of lines and spots shows no evidence of significant change over years, so may be used to identify individual sharks."

Similarly, astronomers are frequently confronted with the task of identifying and precisely locating stars, galaxies, and other celestial objects in images of the night sky. A typical approach, says Arzoumanian, is to locate common objects by identifying their surrounding patterns of stars, essentially the same method marine biologists use to identify individual whale sharks.

Tinkering with an algorithm developed by Hubble Space Telescope astronomers resulted in a whale shark algorithm able to match shark photograph pairs correctly more than 90 percent of the time.

The researchers published their results in a 2005 issue of the *Journal of Applied Ecology* (Volume 42, 999–1011).

To identify spot patterns, scientists select an area directly behind a whale shark's gill slits on the right and left sides. This area can be easily photographed by a diver or snorkeller swimming alongside the shark.

The new technique developed by Arzoumanian, Norman, and Holmberg has been incorporated into the ECOCEAN Whale Shark Photoidentification Library (www.whaleshark.org), an online database that archives digital images submitted by researchers and others.

The algorithm "recognizes" the spots on whale sharks and, from the pattern of those spots, identifies whale sharks. Reliable and frequent documentation of individual whale shark locations are critical to conservation of the species, scientists believe. The new algorithm allows researchers to compare a photograph of a whale shark with all such photos, in minutes. Marine biologists no longer need to spend hours comparing one photograph to a library of identified whale sharks.

The pattern-matching technique was applied in database scans: as new whale shark photographs were submitted to the ECOCEAN library, spot data were extracted and compared with patterns from all previously submitted images, separately for right and left flanks. "These archivable 'digital fingerprints' can be used as natural markers to track individual fish over wide geographic areas, and over time spans much longer than can be achieved with other tracking techniques," says Holmberg.

The implications of this capability for management and conservation may be far-reaching, say the researchers. For migratory animals like whale sharks, questions remain about whether conservation efforts should be focused at the local or international level. "Identifying individuals with this method will lead to more accurate observations of whale shark maturity, growth rate, and foraging ecology," says Norman.

Using the astronomical pattern-matching algorithm, the scientists have discovered that many whale sharks come back again and again to locations in Australia, the Maldives, and Honduras. One area, Ningaloo Marine Park in western Australia, is a place where immature males feed, a possible critical habitat for this species, says Norman.

Important clues to the ultimate future of whale sharks might be found, it turns out, not in the seas, but in the stars above.

REIGN OF THE JELLYFISH

JELLYFISH OVERTAKE FISH IN NAMIBIAN WATERS. For years, marine ecologists have warned that populations of jellyfish might overtake those of fish in degraded coastal waters. It appears that their predictions have come to pass, according to Christopher Lynam and Andrew Brierley of the University of St. Andrews in Fife, Scotland. Lynam, Brierley, and colleagues published their conclusions in a 2006 issue of the journal *Current Biology* (vol. 16, no. 13).

"Over the past half-century, fishing has led to a reduction in the trophic level of commercially landed species, with a significant decline from large predatory fish to plankton-eating pelagic species and low trophic-level invertebrates," says Lynam. A likely endpoint of this "fishing down of marine food webs," he says, "is a proliferation of previously suppressed gelatinous plankton."

The jellyfish aren't just coming, however, they're here.

"Off Namibia this transition has already occurred," says Lynam. "Jellyfish biomass there [12.2 million tons] currently exceeds the biomass of once-abundant fish [3.6 million tons]."

This profound ecosystem change, scientists say, has possible consequences from fish stock recovery to carbon cycling.

The northern Benguela current system off Namibia is a productive, eastern-boundary current ecosystem fertilized by upwelling of nutrient-rich waters. Historically, the region supported large stocks of fish, including sardines and anchovies, but fishing pressure has reduced those stocks. Total annual landings of commercial fish species have fallen from around 17 million tons in the late 1970s to just one million ton today.

Before this period of heavy fishing, jellyfish were not abundant in the Benguela current ecosystem. Reports from plankton sampling in the 1950s and 1960s don't mention large jellyfish, although numerous small gelatinous zooplankton such as ctenophores, or comb jellies, were observed.

"After early collapses of pelagic fish stocks in the 1960s, reports of conspicuous jellyfish became increasingly common," says Lynam. "Since the 1990s, news of these jellyfish has been ever-increasing, particularly because of the nuisance they now cause." Their bad rap seems deserved: they're bursting trawl nets and spoiling fish catches; jamming power plant cooling intakes and hindering diamond mining by blocking alluvial sediment suction instruments.

"The term 'jellyfish explosion' aptly describes the current situation," says Lynam.

He and colleagues conducted a series of research cruises to study jellyfish off Namibia. The most recent, in August 2003, was a survey to map distribution and estimate biomass. The scientists used multi-frequency echosounders and trawl nets to sample jellyfish and fish along the entire Namibian shelf between the Angolan and South African borders, from the 25-meter to the 350-meter depth contour, an area of 33,710 square nautical miles (115,625 square kilometers).

Perhaps most concerning, says Lynam, is that ecosystem shifts from dominance by fish to dominance by jellyfish may be irreversible. "Jellyfish eat fish eggs and larvae, and are strong competitors for fish food. Thus, they may impede the recovery of fish stocks—even after overfishing stops."

Jellyfish proliferation may also be driven by climate. An El Niño event in 1963 contributed to the sharp decline of sardines off Namibia, which may have been the beginning of the reign of the jellies, Lynam believes.

If more recent climate patterns, such as those of the North Atlantic Oscillation, persist, says Lynam, "it could result in outbreaks of jellyfish in coastal waters on both sides of the Atlantic Ocean. Such outbreaks are trophic dead ends: jellyfish have few predators."

Marine ecosystem managers and modelers can no longer ignore jellyfish, says Lynam, "at least not in an era of what can only be called 'jellyfish ascendancy.'"

Left. *Aequorea aequorea* jellyfish collected on the Namibian shelf. Right. Large compass jellyfish (*Chrysaora hysoscella*) caught in the Namibian Benguela from R/V *Dr. Fridtjof Nansen*. *Photos courtesy of Andrew Brierley, University of St. Andrews, UK*

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