WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

OCEAN explorer

For the Young Associates of Woods Hole Oceanographic Institution Vol. 2 No. 3 March 1993

Computer image of ABE (Autonomous Benthic Explorer) visiting a garbage dump. *(See page 7.)*

SEEING IS BELIEVING

How Oceanographers Glimpse the Hidden Seafloor

Over 70% of the earth's surface is covered by sea water. Only about 1% of the ocean and the ocean floor has ever been explored. Being able to see vast sweeps of the ocean floor, in detail, has long been the wish of many oceanographers.

Yet the ocean—especially the deep ocean—does not reveal its secrets easily. It is probably the most hostile environment on earth to humans. Mostly dark, very cold, with pressure many times greater than on land, only a few thousand people have ever been there, and even then, for only for a few hours at a time, in submersibles like WHOI's *Alvin*. From a submersible, scientists peer out tiny portholes at enormous features, such as mountains as high as any on dry land. But because sea water is opaque, it's only possible to see a very short distance. Even with a vivid imagination, it's hard to get a sense of the big picture.

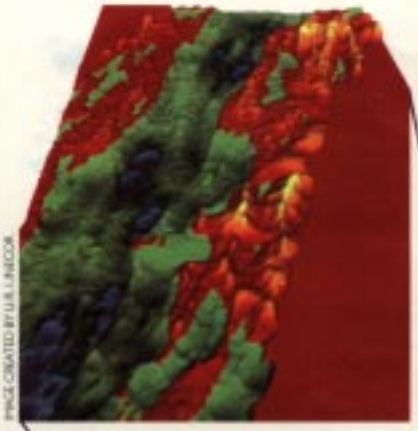
Much is known about the deep sea in a very general way, thanks especially to techniques that use acoustics (sound) to create images. *(For more information on this, see pages 2-3.)* Oceanographers are always improving the imaging tools they rely on.

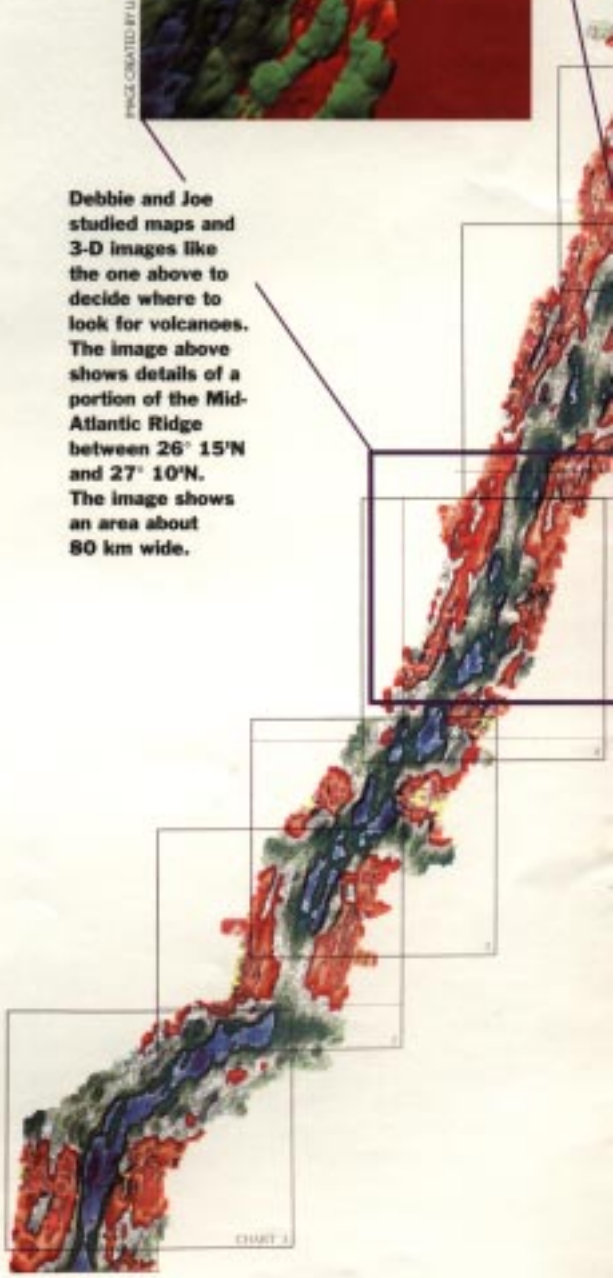
In this issue, *Ocean Explorer* visits some scientists who are devoted to seeing what is so hard to see, as they work to unravel the mysteries of the deep.

Do You See What I See?

To Find A Volcano on the Ocean Floor, Sometimes You've Got to Trust Your Instincts

Debbie Smith on deck.



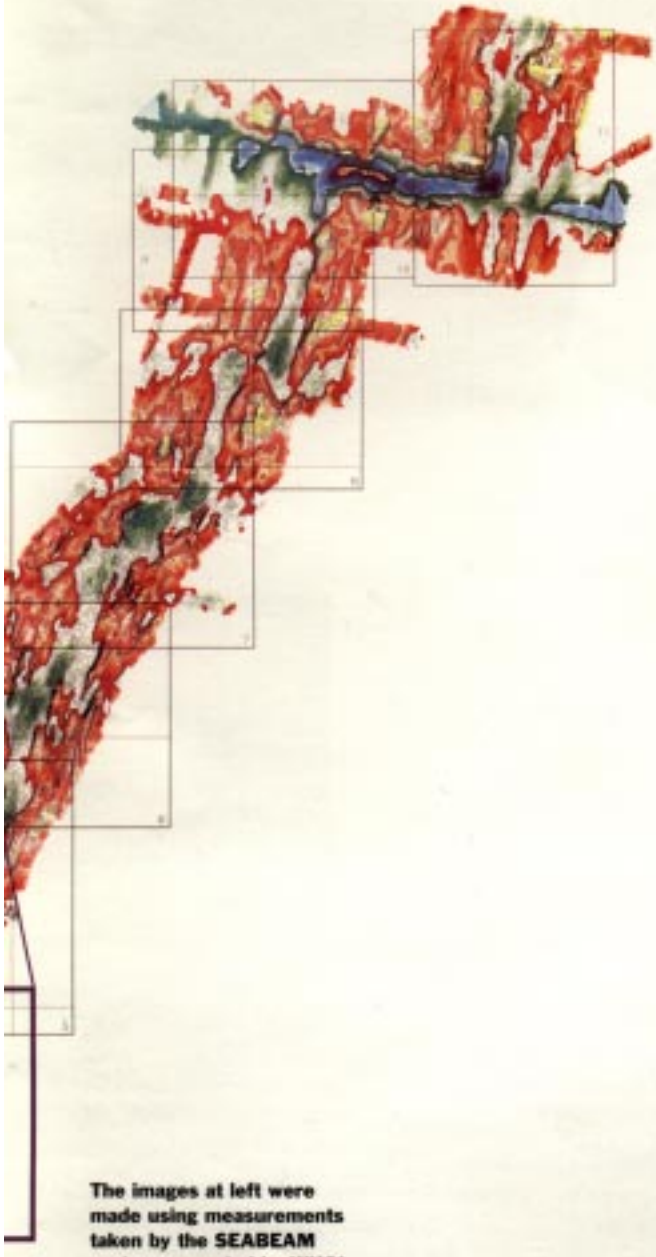


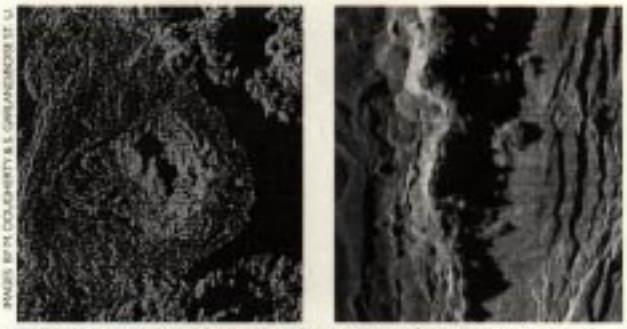
Debbie and Joe studied maps and 3-D images like the one above to decide where to look for volcanoes. The image above shows details of a portion of the Mid-Atlantic Ridge between 26° 15'N and 27° 10'N. The image shows an area about 80 km wide.

Debbie Smith, a geologist at WHOI, studies volcanoes. The volcanoes she is interested in are not too easy to find, because they are in the ocean. Many volcanoes in the ocean are along the Mid-Ocean Ridge, part of the 70,000 km-long underwater mountain chain that circles the globe like the stitches on a baseball.

Finding these volcanoes is very hard work that requires state-of-the-art technology, patience, and intuition. "We still know very little about the ocean floor," says Debbie. "A lot of what we know is by inference."

To find volcanoes, Debbie starts by looking at bathymetric (depth-measuring) maps, like the ones shown on these pages. The different colors on the bathymetric maps represent different depths from the sea surface. These maps were created with a measurement system called SEABEAM. SEABEAM, which travels to sea attached to the hull of a research vessel, is an acoustic system. That means it gathers the data that will be used to make images by producing a series of sounds. Echoes of those sounds travel from the seafloor back to SEABEAM's receivers. Then the receivers measure how long it took for the echoes





IMAGES BY M. DOUGHERTY & S. CARLANDSCHOOL ST. U

TOBI images of a deep-sea volcano *(l.)* and a ridge *(r.)*, called "Tadpole" (both about 1 km wide). Both were found in the area inside the purple box on the map at left.

The images at left were made using measurements taken by the SEABEAM system, operated by WHOI scientists during two separate one-month cruises. In each cruise, a research vessel with the system mounted on its hull travelled back and forth over a section of the Mid-Atlantic Ridge between 24°N and 31°N as the device recorded the depth of the seafloor at set intervals. The data that the SEABEAM system collected was input into a computer program that created the images.

The long map on pages 2-3 shows an area that is about 80 km wide and more than 800 km long.

to travel. During the cruise, scientists input those measurements into computer programs. The programs use the data to draw maps, like the long map shown at left, and 3-D images like the one shown on page 2. Both show the heights and outlines of seafloor features at sections of the Mid-Atlantic Ridge.

FOLLOWING A HUNCH

If you look at the SEABEAM maps, you can see that it is very hard to identify specific seafloor features, in detail. It's a little like looking at a mountainous landscape from the window of an airplane. But Debbie and a colleague, Joe Cann of Great Britain's University of Leeds, became convinced that the area in the purple rectangle represented volcanoes. Many other geologists studied the same map and did not come to the same conclusion. "How do you know?" the other scientists challenged Debbie and Joe. Of course, Debbie and Joe did not know for sure. But they had been studying images like these for a long time, and they had a strong hunch. They decided to follow their hunch, to see if they were right.

The British Government agreed to send a ship to the site, along with Debbie, Joe, other scientists, and a sonar system called TOBI (Towed Ocean Bottom Instrument). Like SEABEAM, the TOBI system uses sound to collect data to make images. But TOBI can travel much closer to the deep seafloor than SEABEAM, and therefore produces much more detailed images.

Debbie and Joe were right. TOBI sent back many pictures of volcanoes and other features at the site. Two of the TOBI images are shown above. TOBI imaged some volcano formations that nobody had ever seen before, including some dome-shaped volcanoes with rims that Debbie and Joe nicknamed "wide-brimmed hats." They have learned a lot about the seafloor by studying the TOBI images.

THE SEA BECKONED

Debbie decided to study oceanography after she spent two years on a sailboat. Though she had already been to college, she had to go back to school to take science courses. After that, she went to graduate school, and finally arrived at WHOI six years ago.

Debbie enjoys her work. She hopes to return often to the volcano-studded Mid-Atlantic Ridge to see what she can see.

One Picture Is Worth a Thousand Gigabytes*

From March 1-12, 1993, the JASON Foundation for Education will conduct its fourth annual electronic field trip for students around North America and Great Britain via satellite hookup. The JASON Foundation was established by Robert Ballard of Woods Hole Oceanographic Institution and a number of sponsors to show students the excitement of scientific exploration. This year's JASON Project is broadcasting live from Guaymas Basin, off the coast of Mexico's Baja California. There, scientists from WHOI and other institutions will study hydrothermal vent systems. (See Ocean Explorer, *September, 1992, for more on vents.) The Project will also study gray whales at the San Ignacio lagoon. Recently,* Ocean Explorer *spoke with two members of the JASON project team, Veronique Robigou of the University of Washington at Seattle and Ken Stewart of WHOI.*

VERONIQUE ROBIGOU

Veronique Robigou is a marine geologist at the University of Washington in Seattle. She studies hydrothermal vents at mid-ocean ridges. For several years, she has mapped in detail hydrothermal vent sites on the seafloor. "I'm trying to get as clear an idea as possible of what these areas look like in three dimensions," she says. The undersea area that she studies most often, on the Juan de Fuca Ridge, is not too far from her home in Seattle.

For years, Veronique has worked to understand what the ridge looks like

by studying videotapes made during *Alvin* dives, and by actually diving in *Alvin*, which she loves to do. Veronique appreciates the opportunities she gets to dive in *Alvin*. "Suddenly, you realize you're one of the few people who have ever been down that deep." But trying to get the sense of a gigantic underwater mountain by looking out a tiny porthole has its limitations. "The visibility is limited, the perspective is limited," she says. "You try to get a good feel for what you're seeing, you try to build an image in your brain, but it's not an image that the eye can pass directly into the brain," she explains. It's a little like trying to imagine what an entire jigsaw puzzle would look like, if you could only look at a few pieces of it at a time.

Last year, Veronique went on her first cruise to Juan de Fuca that used the remotely-operated vehicle (ROV) *Jason* instead of the submersible *Alvin*.

Jason carries no passengers. Instead, scientists who use *Jason* remain on the deck of the mother ship, sitting in a control van, watching a bank of monitors that display the massive amount of visual information that *Jason* sends back.

Because the video and still cameras mounted on *Jason* face in several directions, the ROV can "see" more than a scietist peering out of *Alvin's* porthole can. Juan de Fuca, the area that *Jason* travelled through, was one Veronique had studied for many years. But until her first *Jason* cruise, she had never before seen so much of the area, in so much detail. "It was fantastic. My mouth plopped open," she remembers. "I was so amazed at what I was looking at. This time I could see much farther."

On a *Jason* cruise, teams of scientists and technicians work in round-the-clock shifts in the van on deck. The van is filled with computers, television monitors, scientists and

*A gigabyte is a billion bytes of data. Each byte represents a combination of eight bits. Each bit is the number 1 or 0. Here is a byte: 01010101. Computers speak in bits and bytes.

JOANNA BILLY NATIONAL GEOGRAPHIC SOCIETY

A day in the life of *Jason*. The ROV is lowered into the ocean for a dive *(center)*; a busy scene inside the control van *(right)*; giant crabs (18 inches from foot to foot) on lava, photographed by *Jason (upper left)*; "black smoker" hydrothermal vent, with tube worms nearby, also photographed by *Jason*.

technicians. One scientist directs the dive, and other people, seated at work stations, are responsible for different aspects of *Jason's* operation. Many tasks are going on in the van at the same time. Different people are taking navigation readings, recording sonar information, operating the video and still cameras mounted on *Jason*, entering data, and keeping track of all the images that come through. One person pilots *Jason* by moving a joystick, sort of like the ones used when playing computer games.

On some dives, Veronique has been the lead geologist. When in this role, she feels like she could use a hundred pairs of eyes. "I keep moving my eyes back and forth between the sonar and the video screen to know where the ROV is. I watch the video cameras to tell the pilot what to do. I direct the movements I would like him to make with *Jason*. I say: 'Go here! Stop there!'"

After the cruise, it usually takes Veronique a long, long time to understand all that she's seen. As Bob Ballard says, "it's a firehose of data, and you're just trying to take a sip with your mouth." Veronique adds, "it is quite overwhelming."

Working with an ROV is exciting. "It is wonderful to work with ten people around you, discussing problems as you go, making decisions really fast," says Veronique. "One of the purposes of *Jason* is to allow many people to participate. Suddenly a much wider community is able to study the deep sea."

TORI CORSATTI/WHOI

During the JASON Project trip to the Guaymas Basin, Veronique will try to create a map of the seafloor. This will be the first time she's collected data while thousands of students watch her work.

"It will be a challenge to do my science and talk to all the people at the same time," she says.

KEN STEWART

"If only we could remove the water," sighs scientist and engineer Ken Stewart of WHOI's Deep Submergence Lab, as he describes the difficulties in his career-long effort to help fellow scientists see the ocean floor in detail.

Ken says he is a "toolmaker and a tool-user." He designs and builds computer-based deep-sea sensors. "I'm trying to turn bits and bytes into useful images," he explains. Ken is one of the people responsible for the development of *Jason*. He is in charge of *Jason's* "eyes," its ability to send back images from the sites it visits, via sonar, video cameras and a still digital camera.

Jason's abilities are *(continued on page 6)*

constantly being refined and improved by Ken and others he works with. For example, as Veronique Robigou said, the images that *Jason* sends back appear simultaneously, but on several different monitors in the crowded, busy, on-deck van from which the remotely-controlled dive is run. It's up to the scientists and technicians studying those images to blend them in their brains as they look at them.

Ken is working to merge those separate types of images into one. This will create what Ken describes as "a very accurate three-dimensional image of the area being studied." Ken calls this a "fly-through image," and he hopes it will help scientists better understand what they are looking at.

Down the road, Ken hopes to invent what he describes as the ultimate deep-ocean tool: an untethered (free-swimming) vehicle that can navigate its way around the deep sea floor by following a three-dimensional map of the area that is built into its "brain." This would be a true underwater robot. (*Jason*, by contrast, is not a true robot. Each move it makes is initiated by a pilot operating a joystick.)

Creating an untethered underwater robot that can self-navigate within its world is a huge challenge. Ken says, "You send a vehicle down there. It's got to avoid bumping into something. It's got to perceive the object. How will I tell it to do that?" Before he can create such a device, Ken believes, "we need to have a much better understanding of how our own senses operate."

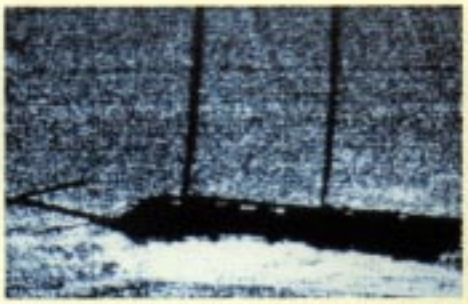
Ken came to WHOI almost eleven years ago as a graduate student interested in free-swimming underwater vehicles. The son of an engineer, Ken has known he wanted to be a scientist since he was twelve years old. "I always liked to take things apart and put them back together again," he explains.

Ken grew up near the ocean, and believes "oceanographers have salt water in their veins." Going to sea is, for Ken, "the joy of this work. That's what drew me in and that's what keeps me excited."

During the JASON Project Ken will be where he loves to be, at sea, in the on-deck van, helping other scientists work with data the ROV is collecting about the seafloor.

Three Images from *Jason's* Scrapbook

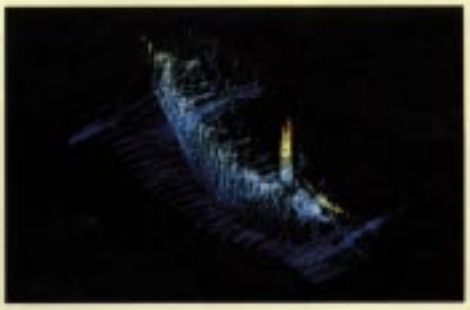
In addition to its regular oceanographic cruises, *Jason* has served as an invaluable aid to underwater archaeologists who search for sunken ships. Here are some examples of images *Jason* sent back from sites where sunken ships have been located. These images are of the *USS Scourge* and the *USS Hamilton*, merchant ships that were converted to gunboats of the U.S. Fleet during the War of 1812. *Scourge* and *Hamilton* capsized and sank during a storm on August 8, 1813. Both ships now lie underwater near Hamilton, Ont., at the bottom of Lake Ontario. Three years ago, the JASON Project team travelled to the site of the submerged ships. *Jason* sent back some ghostly images.



***Jason's* two-dimensional sonar image of the *USS Scourge* shows that the ship sank virtually upright. After being on the floor of Lake Ontario for almost two hundred years, it is in surprisingly good shape.**

***Jason* captured this image of the carving on *Hamilton's* bowsprit.**

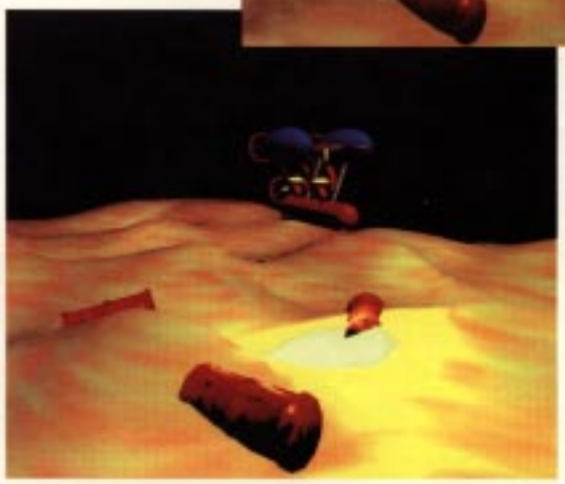
This is a three-dimensional sonar view of the *USS Scourge*, created by *Jason*.



ALL IMAGES COURTESY ENGE & KEN STEWART NAVICO

Virtual Reality Comes to the Deep Sea

Will a computer soon take you on an imaginary voyage to the deep sea?



IMAGES BY DAVE GALLO WHOI MADE WITH SPYGLASS AND INFINITE IQ SOFTWARE

Two images from Dave Gallo's Virtual Ocean program show ABE (Autonomous Benthic Explorer) visiting a deep sea garbage dump.

"In outer space, you can see for an eternity," says Dave Gallo, Director of Corporate Research and Technology Programs at WHOI. "Underwater, you can't see beyond the end of your hand." He's exaggerating, somewhat. From earth, we can see the stars of galaxies that are millions of light years away. Deep beneath the sea, even using very powerful lights, it's hard to see much farther than the distance across a room. Dave believes computers can help more people see more of the sea floor. To help achieve this goal, Dave is working with a new type of computer technology called virtual reality.

DAWN OF THE AGE OF VIRTUAL REALITY

The notion of virtual reality was first discussed in 1965 when a visionary computer scientist named Ivan Sutherland gave a talk at a computer convention. In that talk he said, "One must look at the display screen as a window through which one beholds a virtual world. The challenge to computer graphics is to make the pictures in the window look real, sound real, and the objects act real. Indeed, in the ultimate display, one will not look at that world through a window, but will be immersed in it, will change viewpoints by natural motions of head and-body, and will interact directly and naturally with the objects in the world, hearing and feeling them as well as seeing them."

The technique of virtual reality, which is still in its earliest stages of development, will enable a user to do just that. Wearing devices on the head and hands that send simulated sensations, the user will be able to move through an environment as though he or she were really there. If you have ever played a computer game that was so engrossing you almost forgot where you were, you have begun to approach the feelings that a virtual reality user will someday have. In fact, some techniques of virtual reality are beginning to be incorporated into video games and may soon be seen in feature films, as well.

THE VIRTUAL OCEAN

Dave hopes, before too long, to be able to hand out a "Virtual Ocean" on a computer disk, through which a user may simulate piloting a submersible above a simulated ocean floor.

"If I hand someone a Virtual Ocean disk, that person doesn't just read about an underwater volcano in a book," says Dave. "The person can go inside the volcano, and see what's there." From there, the user can go on to examine the next volcano, or into an adjacent valley, experiencing the scale and magnitude of deep-sea features along the way.

Today, Dave's Virtual Ocean only shows a small portion of the total sea floor. To collect this information, he travelled to sea and "mowed the lawn" of an area of seafloor, by directing a sonar device to travel back and forth over the area until it had collected what Dave felt was sufficient information about the details of the area's features. Returning to his office, Dave put the data into a computer program that could turn the numbers into pictures. He added color to the program, so different depths appear in different colors.

By "flying" a simulated submersible through the environment, much the same way an airplane is flown through a computerized flight simulator, it's possible to see what Dave's final end-product will be like. Using it is a little like playing a video game, except it shows a real place (which most people will never visit).

SHARING INFORMATION

Dave Gallo didn't start out as a scientist. "I used to be a shoe salesman," he says. "But I always wanted to explore space." Then, in 1976, he read an article in *National Geographic* written by WHOI geologist Robert Ballard. "I saw a picture of an underwater mountain range in the Cayman Trough. It was an artist's drawing. Next to the mountain was this little thing, this submarine *[Alvin]*. I was staggered." That picture prompted Dave to go back to school to study geology and geophysics. He came to WHOI in 1987, to work with Bob Ballard.

Dave understands why many people want to study outer space, but he's quick to point out that there is still much to learn about our own planet. "Why should we go to space to find other life? There's a place on earth that's as foreign as any far-away planet," he says. "That's the deep sea."