

The
undersea
world
of
David Mindell

MIT professor helps solve the
unique engineering problems
of deep-water archeology

By Tim Haynes
GLOBE CORRESPONDENT

WOODS HOLE - In late June, after an all-nighter of furious last-minute soldering and tweaking, David Mindell, the director of MIT's DeepArch research group, and three of his doctoral students head down to the Woods Hole Oceanographic Institution in Falmouth. They're there for a final real-water test of the ocean-floor positioning technology they've developed. Later this summer, the devices will help provide unprecedented views of ancient shipwrecks buried in layers of sediment more than a thousand feet underwater, too deep for human divers to explore.

After the tests are completed, the equipment will be shipped to the Mediterranean for a six-week research voyage led by Robert Ballard, the discoverer of the wreck of the Titanic. A team of oceanographers, archeologists, and engineers will be using the equipment to scan in detail two Phoenician vessels dating back to 800 BC, the oldest known shipwrecks in the world.

Mindell's imaging innovations are part of an ongoing technological revolution affecting how archeology is being performed. Picks and shovels are being replaced by robotic arms and computer screens, and remotely operated vehicles are allowing access to places humans couldn't reach otherwise: Archeologists need not be physically present.

Aboard the Asterias research vessel, Mindell's team is still tightening screws and lashing parts together with cable ties. Once in 50-foot-deep water, they haul the heavy beacon to the edge of the deck and carefully lower it to the ocean floor, attaching a float to mark its location. Group member Brian Bingham drops the transponder, a sonar transmitter-responder, a few yards over the side of the boat, and checks to make sure that Mindell's notebook computer is receiving the signal. The captain cuts the engine and the boat slowly drifts away from the bobbing float.

The transponder starts sending out sonar signals, or pings, for the beacon to receive and respond to. The goal for the day is simple: See how far away the transponder can communicate with the beacon; the minimum goal is 100 meters (about 330 feet) of range. This pairing is the heart of a location system that will enable Mindell's other new device - a narrow-beam subbottom profiler - to pinpoint its relative position on the ocean floor. The equipment is designed to work together to render accurate topographical maps of buried shipwrecks.

The pings start returning and Mindell and Bingham glue themselves to the computer to watch thin columns of numbers



GLOBE STAFF PHOTO/DAVID L. RYAN

DAVID MINDELL

1 Sonar transmitter/ responders, called transponders, are placed on the sea floor and their positions are precisely calibrated.

2 The remotely operated vehicle sends out sonar "pings" several times per second.

4 Measuring the time delay between its ping and the transponders' responses lets the ROV determine its position within a fraction of an inch.

3 Transponders hear the ROV's pings and respond with their own individual pings.

Deep-water archeology

Using remotely operated vehicles, or ROVs, and high-tech sonar, researchers are able to meticulously scan two Iron Age shipwrecks more than 1,200 feet deep in the Mediterranean Sea - and to bring artifacts up to the surface for further study.

The ROV can run on autopilot, surveying a predetermined area. Photo, sonar, and scanning data are coded for precise positions, allowing researchers to combine images into large, detailed mosaics.

Data are sent to the surface via a cable, letting shipboard researchers operate the ROV in real time and study specific artifacts.

High-resolution sonar scans the sea floor as the ROV surveys, taking extremely precise measurements of artifacts and the terrain.

Force-feedback robotic arms and collection equipment allows researchers to retrieve specific artifacts.

Tightly focused sonar sees below the surface, revealing artifacts up to 6 feet beneath the sea floor.

High-resolution photos are taken of the entire site, allowing archeologists to identify specific artifacts for retrieval.

SOURCES: Woods Hole Oceanographic Institution Deep Submergence Laboratory, MIT's DeepArch research group, American Journal of Archaeology
GLOBE STAFF GRAPHIC / SEAN McNAUGHTON

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Inside the psychopath

Moving ahead on diagnosis and possible treatment

By Carey Goldberg
GLOBE STAFF



AP FILE PHOTO

Not all psychopaths are necessarily serial killers like Jeffrey Dahmer.

Scientists may slowly be closing in on the psychopath. New research tools, from brain scans to psychological tests, are yielding more sophisticated insights into what makes psychopaths such cold-blooded predators, raising the prospect of improved tests to identify them and possibly even treatment. "We can treat most other emotional disorders pretty successfully, and we will be able to treat this one soon," said Dr. James Blair, a researcher at the National Institute of Mental Health. Psychologists estimate that one in every 100 people is unfeeling enough to qualify as a psychopath, with an especially heavy concentration among criminals. The ranks include serial killers such as Ted Bundy, who charmed and killed dozens of young women in the 1970s, and cannibal-murderer Jeffrey Dahmer, who fatally seduced 17 men and boys before he was caught in 1991, as well as a great many other people who never commit a crime punishable by law, but go through life heartlessly using and manipulating others without remorse. Blair is an admitted optimist, but even skeptical scientists say that the last few years have brought progress, as researchers have largely reached agreement on how to define a psychopath and have begun pinpointing what happens in their brains.

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1 in every 100 people
is unfeeling enough to qualify as a psychopath

Undersea world of David Mindel

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bers scroll up the screen.

"We're at 100," Bingham says, . . . 105 . . . 110 meters. . . 130 . . . 135 . . . 135 . . . lost it."

The ship's engine cuts in and the boat starts heading back in the direction of the beacon.

"Well, we've passed our minimum happiness threshold, so we can go home happy no matter what," Mindell says.

But once they raise the signal power, the tests improve, and they manage to maintain communication for almost 300 meters, well beyond expectations.

A soft-spoken, unassuming, 30-something with glasses, prone to wry smiles, deft explanations, and the occasional understatement, Mindell is to depart Sunday for the Mediterranean, where, as part of the Ballard expedition, he will finally field test his new equipment. "We may call these trips 'cruises,'" he said, "but they're really quite grueling. With less effort, I wrote two books."

The central engineering feat of Mindell's work is the subbottom profiler, which does the actual ocean floor imaging. For the cruise, the profiler will be attached to the underside of the Hercules 2 remotely operated underwater vehicle, along with the positioning transponder.

Visually, the profiler is a flat, footlong solid-black block, but it's actually "just a big underwater speaker and a microphone," Mindell explained.

"This thing sends a very narrow sonar beam into the mud and then what's buried reflects back, and you can see the difference between what's sediment and what's something hard, like wood or metal," he said.

Geologists have been using similar technology for decades to map the ocean floor, but they have always used very wide sonar beams because they penetrate hundreds of times farther into the sediment than narrow beams. Wide beams don't have the resolution to pinpoint anything much smaller than a football field, which is fine for mapping large areas, but in rigorous archeology, such limitations make them virtually useless.

With this latest technology, Mindell said he expects the resolution to be fine enough to trace the form of objects as small as 6 inches across — about the width of many of the supporting beams in old ships. But Mindell has an even more detailed vision for the future.

"If you can see a baby's face inside a woman's womb, or they can image the parts of your brain in 3-D without ever going in there, we should someday be able to image that detail with stuff that's buried in mud. This is the first baby step."

Of course, being able to bounce sonar pings off of buried ships isn't very useful without the system for assembling the tens of thousands of pings into a cohesive map of what's under the ocean floor, a task that requires incredible precision in three dimensions, which is where the transponder and beacons come



GLOBE STAFF PHOTO/DAVID L. RYAN

MIT researcher David Mindell works in his lab in the basement of his Cambridge home.

into play.

A pair of battery-powered beacons will be carefully placed on the ocean floor on opposite sides of the wreck. The transponder attached to the Hercules 2 pings the beacons several times a second. The computer measures the time interval for each ping to determine how far the vehicle is from each beacon. The vehicle has a very accurate depth-sensor built in, and the computer combines the depth reading with the two beacon signals to triangulate its position to within a fraction of an inch.

This level of precision makes it possible to guide the vehicle back and forth in a zipperlike pattern, passing over the entire area of the wreck. It takes about four hours to scan the complete area, which is about two to three times the size of a football field.

On this trip, Mindell is scheduled to scan at least four sites — the two Phoenician shipwrecks in the Mediterranean, as well as two sites in the Black Sea. Mindell has visited the Phoenician wrecks before, but never with this kind of advanced equipment. And looking forward, he advocates the advantages of continuing to revisit and remap important sites.

"You want to do it every year at the same site so you can record how the site is decaying or being moved around by the sediments. When you make these precise maps, they are references to each other so you can see the subtle changes over time, and that's not something you can do any other way."

For Mindell, underwater archeology is raising a lot of interesting questions about the ends and means of scientific inquiry as it is being changed by technology. These deep ocean sites will be mapped by computerized sensors, and later unearthed by robotic arms without human eyes ever seeing the artifacts directly, since most of the wreckage will remain on the ocean floor. But Mindell sees the scope of discovery — not the changing technology — as what is really important.

"Archeology is very much about touch," Mindell said, "and a lot of archeologists are very nervous about the fact that they will never be able to be at their sites. What I keep coming back to is, what are you trying to learn; forget about what you are used to doing or the way you like to do it."

Mindell, who stresses that he's not an archaeologist, explained that, as advanced as it is, "this technology does nothing more than digitize the seafloor. . . . How the pictures relate to what's really out there is really the research question. . . . We can make these images, but we still need archeologists there to make the interpretations."

Inside the psychopath

► **PSYCHOPATHS**
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have begun pinpointing what happens in their brains.

Even the last few weeks have brought intriguing new findings. Among them: A psychological test designed to detect unconscious or frowned-upon attitudes picked up a decided tendency among psychopathic murderers to have abnormally positive attitudes toward violence, British researchers reported in the May 29 edition of the journal *Nature*.

No one has ever pinned down that attitude among psychopaths before, said Nicola Gray, coauthor of the *Nature* paper, because they relied on explicit questions, and psychopaths lie a lot.

Spinal taps on more than 50 imprisoned criminals in Sweden produced new evidence that psychopaths may have an imbalance of the brain chemicals serotonin and dopamine, according to a paper in last month's *Journal of Neurology, Neurosurgery and Psychiatry*.

Experiments using brain scanners while psychopaths perform various tasks also have been accumulating.

They suggest that "the psychopath finds it difficult to process, handle, or use emotional material in the same way the rest of us do," said Robert D. Hare, professor emeritus of psychology at the University of British Columbia and widely considered the world's foremost authority on psychopaths.

Of course, that is the obvious problem, the very definition of a psychopath: They lack normal feelings, like empathy and remorse. And researchers have known for decades that psychopaths also tend to show some unusual physical responses: They sweat less and generally exhibit less distress when exposed to frightening or threatening stimuli, for example.

But research is now focusing on the brain abnormalities in psychopaths, said Dr. Bruce Price, chief of neurology at McLean Hospital in Belmont.

And, he said, "the seismic shift is that, up until a decade or so ago, this was the realm of psychologists



1978 UPI FILE PHOTO

TED BUNDY
Charmed, then killed, dozens

and sociologists. We now are at the point where biological science can try to make sense of this."

That point has been reached partly thanks to new tools like brain scanners, researchers say, but also partly thanks to Hare's development of a broadly accepted clinical standard for who is a psychopath, a test called the PCL-R, or psychopathy checklist-revised.

The PCL-R allows psychologists to rate a subject's level of psychopathic behavior and emotional makeup by extensive interviewing and examination of his or her record. (It is almost always a man.) It measures how callously the subject has used others, for example, and how antisocial and unstable the subject's life has been.

The development and broad acceptance of the PCL-R gave researchers a basis for making sure they compared apples to apples across studies. Research on psychopaths has "skyrocketed" in recent years, Hare said, with particular interest in Scandinavia, Germany, the United States and Canada. It was, he said, "a ruler not made out of rubber."

Among all those researchers, those examining brain activity have tended to find abnormal activity in the amygdala, a part of the brain seen as the seat of basic emotions like fear, and the orbito-frontal cortex, which is involved in helping people adjust their behavior in response to reward or punishment.

Some studies also indicate problems in the connection between the deep, emotional brain and the thinking part of the brain.

That anatomical finding combined with psychological tests show with new precision that psychopaths have problems processing emotional information, particularly things that make normal people afraid or sad, Blair said.

And consider, he said, that "the best way of teaching a child to feel guilt about harming another individual is to focus the child's attention on the victim's sadness. But that sort of socialization technique doesn't work well with individuals with psychopathy," because they tend to be unable to feel empathy and to respond poorly to cues associated with negative emotions.

In essence, Hare said, it appears that "emotion for the psychopath is like a second language," one he or she must struggle to speak and never master deep down. Emotions for psychopaths are abstractions, much as they are for Data or Mr. Spock on "Star Trek," he said.

Even their murders tend to be dispassionate: A study of 125 Canadian murderers found that among those with high psychopath scores on the PCL-R, 93 percent of their killings were "instrumental," practical, rather than crimes committed in the heat of high emotion. That cold-blooded quality makes them particularly dangerous, experts say.

So, with all this research, how about a definitive test to catch the potential serial killers before they start killing?

It is conceivable, researchers say, but not yet doable: "The false positive rate would be horrific," Hare said. But, eventually, it should be possible to combine the telltale signs in psychopaths' brains — once it becomes much more clear what those are — with a clinical tool like the PCL-R and get an excellent predictor of future danger, he said.

But to get there would require large-scale, expensive studies, he added.

The psychological test of attitudes toward violence published in *Nature* may be usable to predict how violent a psychopath is likely to be, but more research is needed, according to Gray. A similar test shows promise in revealing attitudes toward pedophilia, she said.

But a Harvard expert on the test used in the *Nature* study, which is called an Implicit Association Test, expressed concern: "The IAT is not, and never will be a test like a DNA test," said Mah-zarin Banaji. "It is meant for research, not diagnosis," she said.

As for treatment, past research has shown that most conventional treatment, like group therapy, only makes psychopaths worse; it seems to train them in manipulating people and faking emotions.

But Blair and some others believe that, within a few years, a drug may be developed to treat psychopaths. People with depression and anxiety problems can be helped by adjustments of their brain chemicals, he said, and psychopaths effectively have the opposite problem in that they feel too little.

"You would be able to help the systems that aren't working particularly well by using a drug, so long as we understand what's not working well," he said. So, perhaps "we can give emotions to people who lack them."

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HEALTH REFERENCE GUIDE

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Taking health risks for the sake of looks

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It's a delicate dilemma for both patients and doctors: "When you lose control over your appearance, you lose control over your own privacy," he said. "You may want to keep your illness to yourself, but when your appearance changes, you are forced to interact with other people about it." An altered appearance can also be a constant reminder to the patient of his or her own vulnerability.

Weight gain is another all-too-visible side effect of many drugs, including those used to treat psychiatric diseases. Some antischizophrenia drugs like Clozaril and Zyprexa trigger an average weight gain of 15 pounds and sometimes 100 pounds or more, said Dr. Donald Goff, a psychiatrist who heads the schizophrenia program at Massachusetts General Hospital.

Not surprisingly, "a lot of patients don't want to take these medications," he said, adding that weight gain "is not just a matter of vanity; it's a serious threat to a person's general health." Fortunately, several newer drugs, including Geodon and the recently approved Abilify, do not trigger weight gain.

Drugs that cause weight gain pose an especially wrenching dilemma for young women with anorexia and bulimia who are already terrified of looking fat, yet need psychiatric medication, said Dr. David Herzog, president of the Harvard Medical School Eating Disorders Center at MGH. Other patients often hesitate to take antidepressants, which sometimes cause weight gain, and some peo-

ple with manic-depression (bipolar disorder) fear lithium for the same reason.

Cancer patients on chemotherapy often face the same dilemma, said Barrie Cassileth, chief of the Integrative Medicine Service at Memorial Sloan-Kettering Cancer Center in New York. Now that there are good drugs to control nausea and vomiting, weight gain is actually viewed as an increasingly common problem, she said. "I don't know that people actually stop chemotherapy because of the weight gain, but it is devastating."

As for Bob, his physician, Dr. Cal Cohen, research director for Community Research Initiative/New England, is supportive of the delicate balancing act between appearance and health.

The advent of better AIDS drugs in recent years has certainly been a plus, Cohen said, but "there are disfiguring toxicities from some of the drugs, which make people look sick. . . . Nobody wants to be with you if you look sick."

Which brings us back to Bob. He's been having monthly injections of a substance believed to boost collagen in the face. He's also decided to go back on his AIDS drugs for three months to "tomp the virus down," then take another year off.

No one knows yet how his gamble will play out. But, for the record, I can't help but admire his clarity about his own values and his willingness to live by them.

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