Deep-sea feast. A baited camera attracts snailfish (*left*) and amphipods (*above*).

MARINE SCIENCE

Ocean's Deep, Dark Trenches to Get Their Moment in the Spotlight

Like Captain Ahab's white whale, deep-sea trenches have lured explorers for decades, tantalizing them with glimpses of an ecosystem shrouded in darkness. The latest to attempt to pierce the gloom, movie director James Cameron, last month took his privately built one-man submersible 10,000 meters down to the deepest point on Earth: the Challenger Deep in the Pacific Ocean's Mariana Trench. Although Cameron's journey to the abyss yielded little new scientific data, it whetted the public appetite for information about life in the otherworldly environments of deep-sea trenches. An international group of marine scientists may soon provide a feast of such data, from the first major systematic study of a deep-sea trench.

If all goes as planned, early next year a 3-year project dubbed HADES (Hadal Ecosystem Studies) will take its inaugural plunge into the Kermadec Trench, a 10,000-meter-deep gash off the northeast coast of New Zealand. There, a team headed by deep-sea ecologist Timothy Shank of the Woods Hole Oceanographic Institution (WHOI) in Massachusetts will use robotic tools to try to answer some long-standing questions about the origin, evolution, and distribution of life in the trenches. In particular, the team—which includes collaborators at universities in the United States and United Kingdom, the National Institute of Water and Atmospheric Research in New Zealand, and the U.K.'s National Oceanography Centre—will focus on the hadal zone, between 6000 and 11,000 meters down. "It's our first look at an ecosystem," Shank says. "This is terra incognita in some ways."

Earlier trench research efforts, starting in the late 1940s, were limited to dragging nets and dredges to collect samples (see Perspective, http://scim.ag/RALutz). HADES scientists, however, will use a broad array of more capable tools, including WHOI's hybrid remotely operated vehicle *Nereus*, which can sample broad swaths of ocean while operating autonomously or tethered to a ship. They'll also have "hadal landers"—baited traps and cameras that freefall to the bottom, record data, and float back to the surface—and devices that can measure the physiology of deep-ocean creatures. "We're not blindly towing a net behind a ship [anymore]," says Jeffrey Drazen, a physiological ecologist at the University of Hawaii, Mānoa.

Drazen and his colleagues will need all these tools to study a habitat no longer viewed as a kind of cold storage where barely anything happens. Past studies have shown that trenches are geologically and biologically active. Formed when a denser tectonic plate sinks beneath a lighter one, they harbor seeps, seamounts, and mud volcanoes, and are even influenced by the moon. Those tidal cycles challenge "the notion that the deep sea is a constant environment," says marine biologist Alan Jamieson of the University of Aberdeen in the United Kingdom. He is studying whether and how cockroach-sized crustaceans called amphipods sense those daily pressure changes. "They may well be entrained to a tidal cycle [even though] they don't know what the moon is," he says.

Scientists are also "learning that a lot of things accumulate in trenches: food, carbon, chemicals, and even our trash," says WHOI's Shank. Researchers have found everything from plastic raincoats to evidence of a Holstein dairy cow.

The Kermadec expedition will also examine how animals deal with the high pressures in the deep sea. Marine animal physiologist Paul Yancey of Whitman College in Walla Walla, Washington, will focus on one of these adaptations: organic compounds called piezolytes. In organisms that live in shallower seas, these molecules help regulate cellular water content. But Yancey discovered that they also defend some deep-sea animals against high pressures. So far, researchers have only studied piezolytes in fish found down to 4900 meters and crustaceans and sea cucumbers down to 2900 meters. No one knows how the molecules function, or how concentrated they are, in animals at nearly 10,000 meters.

The University of Hawaii's Drazen intends to study how food availability in the trench affects metabolism. Fine organic particles drift down from surface waters and are funneled into trenches, settling along their deepest points. That means the food supply likely increases with depth in trenches, and HADES researchers suspect that if food supply determines an organism's metabolic rate, then animals along the trench's axis will have higher rates than ones farther away. They'll test that idea by deploying respirometers, chambers that measure an organism's oxygen consumption, along the Kermadec's 1200-kilometer axis. The researchers will use *Nereus*'s "slurp gun" and robotic arm to catch creatures "and plop them into these chambers" for testing, Drazen says.

Nereus will also conduct systematic video surveys of organisms across and along the trench. The Kermadec sits in a productive ocean, researchers note, in contrast to the Mariana Trench's relatively nutrient-poor waters. That's one reason much of the past "deep work, from a biological point of view, has been done in Kermadec," Jamieson notes

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—and why researchers wanted to return in force. Although scientists already "have an idea of who's there, … we don't know how they interact with each other," Shank says. Ultimately, the HADES team hopes to compare the Kermadec data with older information collected on adjacent, but shallower, habitats called abyssal plains.

Researchers also hope to figure out how animals got into trenches in the first place. One hypothesis is that Antarctic bottom water flowed into Pacific Ocean trenches, bringing animals along with it, Shank says. Over millions of years, tectonic activity isolated the trenches, trapping animal populations and leaving them to follow their own evolutionary paths. Genetic testing of Kermadec creatures could help clarify their history.

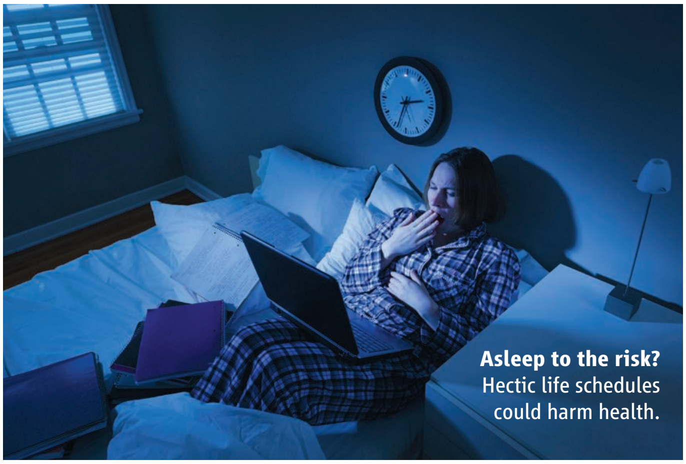
Although HADES is currently funded for work in just one trench, researchers are hoping to dig deep into other hadal trenches. "Trenches are isolated, so what happens at one doesn't necessarily happen at another," Aberdeen's Jamieson says. HADES researchers would like nothing more than to spend the next decade wandering the globe, peering into the gloom. **–JANE J. LEE**

CIRCADIAN RHYTHMS

Sleep Study Suggests Triggers for Diabetes and Obesity

Late nights in the lab, early morning commutes from the suburbs, Angry Birds videogame marathons into the wee hours—the demands and distractions of modern life are stealing our sleep and perhaps robbing us of our health. The longest sleep-limitation study to date, published in *Science Translational Medicine* (http://scim.ag/OMBuxton), found many people are on sleep and work schedules that prime them for diabetes and obesity.

Evidence for deleterious effects of reduced sleep, including a shorter life span, has come largely from epidemiological studies. Although rarer, sleep-intervention studies have begun to suggest physiological mechanisms that might account for such findings. Two years ago, for example, neuroscientist Orfeu Buxton of Brigham and Women's Hospital in Boston and colleagues showed that young men who underwent just a week of reduced sleep had lower responsiveness to the hormone insulin, a decline that is a hallmark of type 2 diabetes.



Asleep to the risk? Hectic life schedules could harm health.

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Our 24/7 society can disrupt our schedules in another way. Humans evolved to be active during the day. Light calibrates the central circadian pacemaker, the body's master clock in the brain. In turn, it helps harmonize molecular clocks in individual tissues so that our physiology and behavior mesh—we get hungry in the morning, for instance, and feel drowsy at night. Studies have suggested that upsetting these circadian rhythms triggers a range of health problems. That's potentially bad news for people who have night jobs or are on rotating shifts, which require them to change work hours frequently; they often have to contend with inadequate sleep and discombobulated circadian cycles.

In their latest sleep study, Buxton and colleagues gauged the physiological impact of this double whammy. For nearly 6 weeks each, 21 study subjects lived in the equivalent of a hotel suite in the hospital's Boston research lab. After storing up on sleep, these people spent 3 weeks on a regimen in which they could sleep for only 5.6 hours in each 24-hour period. Like rotating shift workers, they went to bed at varying times. To throw off their circadian rhythms, the light-dark cycle in the facility lasted 28 hours rather than the usual 24. And to prevent these rhythms from resetting, the researchers kept light levels at the equivalent of twilight or dimmer.

So how did the participants, who went more than a month without Internet access, TV, or contact with anyone outside the facility, cope with these conditions? "Our general impression is that people aren't always their kindest selves when they are sleep restricted," Buxton tactfully notes.

Their metabolism also wasn't at its best. The amount of glucose in each person's blood shot up, with three people reaching levels that researchers term prediabetic. "Over time, much higher glucose levels like that would be expected to be unhealthy," Buxton says. The team identified the likely reason: The pancreas released less insulin, the hormone that spurs cells to absorb sugar. Three weeks of scant sleep and low light levels led to another potentially harmful change: Resting metabolic rate, a measure of energy use, fell by 8%. Over a year, that decrease would translate into a weight gain of nearly 6 kilograms, the team estimated.

These new findings are important because they detail "some potential pathways by which sleep and circadian disruption can lead to obesity and diabetes," says sleep researcher Michael Grandner of the University of Pennsylvania.

After a 10-day recovery period during which the participants stayed in the lab but slept for 10 hours a night and were on a normal light-dark cycle, insulin secretion and glucose levels returned to normal. "Happily, the effect was reversible in our study," says clinical physiologist and co-author Steven Shea, also of Brigham and Women's Hospital. "But if you have years of that [disruption], it may be tougher to reverse."

The next step, Buxton says, is to go beyond lab studies: "My interest is free-range humans." For example, Shea says, it might be fruitful to test blood samples from workers whose shift times change frequently to determine whether their glucose and insulin status mirror those in the sleep study.

Sleep epidemiologist James Gangwisch of Columbia University Medical Center in New York City suspects that the sleep study doesn't reflect reality, however: "I'm not sure too many people are exposed to such extreme shifts in their circadian rhythms."

Nevertheless, he and Grandner agree that the findings from Buxton's team offer a cautionary message. "We live in a culture that prides itself on how little sleep we can get by on," Grandner says. "This study provides more evidence this is not a healthy way of living." **–MITCH LESLIE**

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