

nate shift in the prevailing winds. Just after the 11 March disaster, much of the radioactive contamination from the reactor complex was swept out to sea. But on 15 March, a counterclockwise wind carried contamination back over the prefecture, Watanabe says. “And then it rained.”

Authorities are keeping a close vigil on the patchy contamination. In addition to the sampling by Fukushima Prefecture, the education ministry is monitoring radiation levels nationwide, including at 100 locations in the prefecture. A team from Fukushima University recently mapped radiation levels at 370 spots in the prefecture and, using weather balloons, confirmed that atmospheric radiation levels have dropped to near background levels.

That broad-brush impression of radioactive contamination of the landscape isn’t sufficient for population studies. Shore says it will be important to reconstruct exposures to identify a cohort with the highest exposures. Researchers also need to ascertain where people were during the peak exposure period and where they obtained food and drinking water. Any robust study would also include detailed medical histories and information on smoking habits, diet, and possible exposure to other toxicants, as well as matched controls with little or no exposure. That information “would make possible an informed long-term



Aloft. Fukushima University’s Akira Watanabe is leading an effort to map radiation in the air and on the ground.

cohort study,” Shore says.

Estimating individual doses from environmental data is neither easy nor precise. An alternative technique was developed by a team led by David Brenner, a radiation biophysicist at Columbia University Medical Center in New York City, to plan a response to a radiation release by terrorists. The method rapidly screens blood samples for fragments of DNA and DNA-repair com-

plexes; exposures are calculated based on the number of fragments.

Scientists hope a respected entity will organize a high-quality research plan involving all levels of government. Fukushima Medical University is bidding for that role. A spokesperson has confirmed that the university will establish a research initiative with support from radiation health experts at Nagasaki and Hiroshima universities. Details may be released next month.

Some researchers doubt that any study in Fukushima, no matter how well devised, will reveal much. The radiation exposure of the general population “is too small to give a statistically significant increase in stochastic effects such as cancer,” argues Ohtsura Niwa, professor emeritus of radiation biology at Kyoto University. But even negative data would complement UNSCEAR’s conclusions on Chernobyl, Niwa says, “and, in this sense, have global implications.” As for the linear no-threshold model, Preston says, “I don’t think anything [done in Fukushima] is going to resolve that debate.”

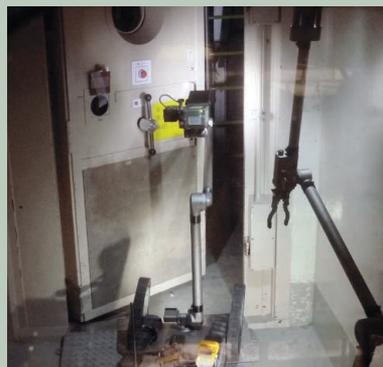
One real effect of the radioactive contamination is the gnawing fear—groundless or not—that low levels of radiation could harm their children. For that reason alone, Yamashita says, “a center or some sort of system to support long-term health follow-ups is definitely necessary.” —DENNIS NORMILE

Crippled Reactors to Get Cooled and Wrapped

TOKYO—The crisis at the stricken Fukushima Daiichi nuclear power plant may have faded from the headlines, but it’s far from over. To cope with the loss of reactor cooling systems knocked out by the 11 March earthquake and tsunami, the plant’s owner, Tokyo Electric Power Co., has installed jury-rigged cooling setups that have cut radiation emissions dramatically. But some 100,000 residents who were evacuated will not return home until the reactors are firmly under control. Last month, Tokyo Electric unveiled a two-stage plan to build more robust cooling systems and reduce radiation leaks within 3 months, then, 3 to 6 months later, achieve a cold shutdown in which fuel is cooled by water below the boiling point at atmospheric pressure.

Nuclear fuel in four of the plant’s six reactors overheated, with extensive core damage in three units. Last week, a robotic inspection increased suspicions that the fuel in unit 1 may have melted through the bottom of the pressure vessel and pooled at the base of the containment structure. Hydrogen explosions completely blew the upper walls and roofs off two units and severely damaged a third; vessels and piping are leaking contaminated water. “There are many challenging tasks ahead,” says Tony Irwin, a nuclear technology expert at Australian National University and the University of Sydney. Workers must reduce radiation levels, plug leaks, and decontaminate water—all while the threat of aftershocks persists.

In the early days, Tokyo Electric hoped to restart Fukushima’s original cooling systems. But the company was forced to explore alternatives, says Hidehiko Nishiyama, deputy director of Japan’s Nuclear and Industrial



Off limits. Robots are finding radiation too high for humans.

Agency. The utility is now planning to build heat exchangers that will circulate fresh water through the reactors to cool the fuel. To seal off reactor buildings, engineers are planning to wrap them in polyester sheets stretched over steel frames. The biggest challenge, Nishiyama says, is protecting workers. Some have been entering the unit 1 building to prepare for construction. But so far, only robots have entered the unit 2 and 3 reactor buildings, where radiation levels top 50 millisieverts per hour. Tokyo Electric may expand the use of robots, which so far have been limited to taking radiation measurements and videos. Because integrated circuits can be affected by radiation, these probes must be primarily mechanical or have hardened electronics. Once new cooling systems and enclosures are in place, work could start on the semipermanent buildings needed for recovering nuclear fuel and decommissioning the reactors, a process that could take a decade or longer. —D.N.

Crippled Reactors to Get Cooled and Wrapped

Dennis Normile

Science **332** (6032), 910.

DOI: 10.1126/science.332.6032.910

ARTICLE TOOLS

<http://science.sciencemag.org/content/332/6032/910>

RELATED CONTENT

<http://science.sciencemag.org/content/sci/332/6032/912.full>
<http://science.sciencemag.org/content/sci/332/6032/908.full>
<http://science.sciencemag.org/content/sci/332/6032/911.full>
<http://science.sciencemag.org/content/sci/332/6032/909.full>
<file:/content/sci/332/6032/news-summaries.full>

PERMISSIONS

<http://www.sciencemag.org/help/reprints-and-permissions>

Use of this article is subject to the [Terms of Service](#)

Science (print ISSN 0036-8075; online ISSN 1095-9203) is published by the American Association for the Advancement of Science, 1200 New York Avenue NW, Washington, DC 20005. 2017 © The Authors, some rights reserved; exclusive licensee American Association for the Advancement of Science. No claim to original U.S. Government Works. The title *Science* is a registered trademark of AAAS.