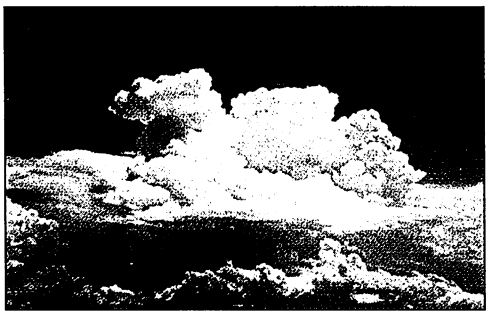

Neighbor effect? A seeded cloud may make adjacent clouds rain more, too.

began. That difference was statistically significant at the 95% confidence level. "They are exciting results," says Daniel Breed of the NCAR group. "There's obviously something going on." Terblanche takes the Mexican results "as a verification of the South African results in a different part of the world. It's confirmation."

Cloud physicists in and out of the weather modification community are also encouraged, but they and the experimenters themselves still have reservations. For one, the Mexican results may be statistically significant, but funding—all of which had come from the state of Coahuila bordering central Texas—dried up once the northern Mexico drought eased. The funding loss prevented a fourth season of operations that should have strengthened the results. And neither the Mexican nor the South African experimenters measured actual rainfall on the ground, only the strength of the radar reflection from raindrops. Because radar is far more sensitive to the size of raindrops than to their number, a few very large drops could have made it appear that seeding triggered more rain than actually reached the ground. In his own computer modeling of hygroscopic seeding, "we definitely see an increase [of rainfall] on the ground," says Zev Levin of Tel Aviv University, "but it's not as much as the radar shows. You still need to do measurements on the ground."

Especially worrisome is that researchers don't fully understand how this seeding works. Although rainfall is enhanced in the 20 to 30 minutes after seeding starts, as the coalescence hypothesis predicts, the most dramatic increases come more than 30 minutes after seeding, and seeded storms rain 30 minutes or more longer than unseeded storms. "It points out there are many things we don't understand about clouds," says Verlinde. Such mechanistic "black boxes" in earlier weather-modification experiments helped trigger implosion of the field in the 1980s. More field studies and more modeling will be required to sort out the possibilities. They include precipitation-enhanced downdrafts that feed back into updrafts. But whatever the explanation, the current results are bringing researchers the first few drops of hope after a long, dry spell in their field.

–RICHARD A. KERR

MARINE MAMMALOGY

Japan's Whaling Program Carries Heavy Baggage

The Institute of Cetacean Research in Tokyo is the scientific arm of Japan's controversial whaling research program. What has it contributed to the field?

TOKYO—Science is supposed to be an international enterprise, but when it comes to research that requires killing whales, Japan is pretty much on its own.

Japan's recent decision to add two species to its scientific haul—which until now has targeted minke whales—has revived the question of whether the real purpose of the program is research, as Japan claims, or keeping the country's whaling industry alive. And although the political and ethical aspects of the debate tend to overwhelm any discussion of the science, the answer seems fairly clear: Although researchers agree that the work is scientifically rigorous, its focus on providing data for managing whales as a sustainable marine resource has generated data of marginal interest to the mainstream marine mammal community. "I think that they are contributing to a large, existing body of knowledge," says ecologist Randall Davis of Texas A&M University in Galveston. "But it's not startling new information."

The basis for Japan's whaling program is a clause in the 1946 International Whaling Convention that allows taking whales for scientific research. Japan has used the clause, which effectively provides a loophole through the 1983 global moratorium on commercial whaling, to allow its scientists to catch and analyze hundreds of minke whales each year as part of an ongoing study of whale stocks. Its efforts generated a political storm that had stalled over the years—until Japan announced this spring that it planned to extend the hunt to a small number of Bryde's and sperm whales. In July, the International Whaling Commission (IWC) registered its unhappiness, saying that the new plan was seriously flawed.

However, Japan pushed ahead, and last week President Clinton responded by banning Japanese whaling ships from U.S. waters, a largely symbolic act that nonetheless underscores U.S. concerns about Japan's research program. "We think that they are abusing the rights afforded them under the convention, and we certainly see no good reason to expand the research to Bryde's and sperm whales," says Mike Tillman, science director at the U.S. government's Southwest Fisheries Science Center in La Jolla, Cali-

There's a catch. Scientists from the Institute of Cetacean Research prepare to analyze a sperm whale caught this month during Japan's expanded harvest.

CREDITS: (TOP TO BOTTOM) NCAR; THE INSTITUTE OF CETACEAN RESEARCH/AP PHOTO

fornia, and deputy U.S. commissioner to the IWC, which enforces the convention.

The war of words has largely ignored the body of work by Japanese scientists. "We're proud of the research we do here," says Seiji Ohsumi, director of the Institute of Cetacean Research (ICR), the scientific arm of Japan's whaling program. "You just can't do this work without taking the whales." But biologist Greg Donovan, a 20-year employee of the IWC's secretariat in Cambridge, U.K., and editor of its *Journal of Cetacean Research and Management*, is more circumspect. "I don't think anyone can say there aren't any scientific results coming out of this," he says. "It is really a value judgment: Do the results justify sacrificing the animals?" And on that question, he says, "there isn't unanimity."

The 1946 whaling convention, which 40 nations have pledged to follow, allows countries to issue permits for taking whales for research purposes. The permits must be reviewed by the IWC's scientific committee, a panel of 120 scientists who examine the aims and methodology of the research plan, its likely scientific payoff, the availability of nonlethal alternatives, and the impact of the research on whale stocks. The committee's review is only advisory, however, and countries are free to issue annual permits. Canada, the United States, the Soviet Union, South Africa, and Japan were among several countries that did so before 1982, but in recent years Japan has stood alone.

Japan has long argued that the moratorium was adopted because of insufficient and misunderstood data. So in 1987—the year the moratorium went into effect—it created the new institute out of an older entity and gave it the job of supplying the IWC's scientific committee with a steady flow of data.

The institute, with 35 scientists and technicians plus support staff, has an operating budget of $73 million. It recoups slightly more than half that amount from selling the whales it captures, a sore point among environmentalists who see the income as proof of the program's commercial focus. Except for small contributions from the fisheries industry, the government provides the balance. Its research ships and crews were previously engaged in commercial whaling, and are now owned and operated by a subcontractor.

ICR operates a program in the Antarctic that, since 1987, has taken 400 minke whales a year. A second program, involving the killing of 100 North Pacific minke whales annually, ran from 1994 through 1999. The U.S. government unsuccessfully urged international sanctions in response to the launch of both programs. This year's new initiative allowed for capturing up to 100 minke, 50 Bryde's, and 10 sperm whales in the North Pacific in addition to the minke whales taken in the Antarctic. Crews returned home last week with a take of 88 whales, including 43 Bryde's and five sperm whales.

The research program involves both sighting surveys and capturing whales. The ICR scientists record 100 data points, including size, weight, age, sex, and stomach contents. They also collect tissue samples to check for such things as accumulated heavy metals, which can be an indicator of pollution levels. Donovan says that the Japanese program is one of the primary sources of data for the committee's efforts to model minke whale stocks for a resource management plan under development. An IWC review of the North Pacific program, completed earlier this year, concluded that the data were relevant to the plan but ducked the question of whether they could have been obtained by nonlethal means.

At the helm. Seiji Ohsumi leads the Japanese institute into controversial waters.

That's not unusual, says John Bannister, an Australian zoologist who chaired the review panel and who is a former chair of the IWC's scientific committee. When there's no consensus, he says, the reports "reflect differing views but come to no conclusions." The sticking point for the committee was the value of the additional data gathered from taking whales, such as their age. Bannister says it is generally agreed that the only reliable way to determine age is to study the buildup of protein in the whale's ear, which can only be done "off a carcass."

Biologist Steven Katona, president of the College of the Atlantic in Bar Harbor, Maine, says that such data are not a good enough reason to kill the animals. "In my opinion, most people wouldn't sacrifice an animal solely to know how old it is," he says. But Doug Butterworth, an applied mathematician at the University of Cape Town in South Africa who specializes in fisheries assessment, argues that taking the whales is justified. "Age data is important, because it provides information about the potential growth rate of the population and the levels at which it can be safely harvested."

There is similar disagreement over the value of studying stomach contents. "Much of what we need to know about [feeding habits] is known to some extent, and there are other techniques for studying diet," Katona says. Biopsy darts to retrieve tissue, for example, would provide an indication of caloric intake, although Katona acknowledges that they would not reveal what species were being eaten. Ohsumi insists that the only practical way of studying what whales eat is to study their stomach contents, which requires killing them. He says that whales are probably in competition with humans for fish and that understanding this interaction, a key element of the new program with Bryde's and sperm whales, will be essential for managing all marine resources.

Tillman scoffs at that rationale, however. "We think that any research should focus on the management of whale stocks, not fisheries," he says. "Toward that end, there's no good reason to learn the amount of prey being eaten."

Butterworth sees "a bit of a con" on both sides of the debate. He agrees with those who say Japan's major objective is to keep its whaling fleet intact. But he notes that Japan wouldn't be doing any research at all, including the noninvasive sighting surveys, if the program didn't recoup part of its expenses from selling the whales. And he accuses opponents of making misleading conservation claims—which ignore the fact that minke whales are relatively plentiful and have never been listed as endangered—when their real objection is based on ethics.

Robert Brownell, a member of the scientific committee and a colleague of Tillman's, admits that taking a few sperm whales isn't a threat to the stocks. "But there is a question of trust ... and where this is all leading," he says. What scientists fear, he says, is that Japan will use scientific data to justify a return to the bad old days of unregulated commercial whaling.

Japan has never made a secret of its hope of resuming commercial whaling, Ohsumi says. But he thinks it should be done right. "We don't understand why whaling shouldn't be managed in the same way other commercial marine resources are managed," he says.

–DENNIS NORMILE

With reporting by Jeffrey Mervis.

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