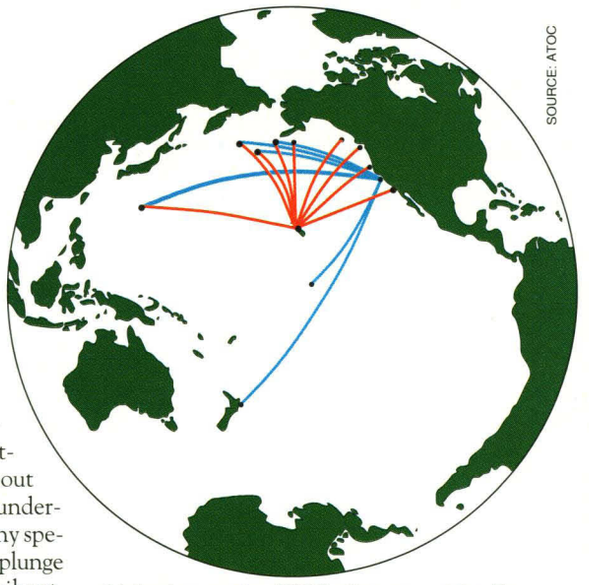
OCEANOGRAPHY

ATOC Delayed as Report Laments Research Gaps



SOURCE: ATOC

Listening posts. ATOC sites around the Pacific Rim are ready for the broadcasts.

A seven-nation, $35-million attempt to use underwater sound waves to measure whether the world's oceans are getting warmer has been temporarily derailed by protests from those who say the federally funded experiment could harm whales, dolphins, and seals in the vicinity of the broadcast sites. The clamor over the scheduled research coincides with the release of a report from the National Research Council (NRC) that emphasizes how little is known about the impact of low-frequency sounds on marine mammals, and urges the government to lower the barriers to researchers who wish to conduct such studies. Ironically, the NRC report calls for exactly the kinds of studies that were being planned as part of the stalled experiment, known as Acoustic Thermometry of Ocean Climate (ATOC).

Plans for ATOC have been in the works ever since a similarly controversial experiment in January 1991 off Heard Island in the Indian Ocean established the feasibility of detecting minute changes in ocean temperature by measuring the speed of sounds broadcast through thousands of kilometers of ocean (*Science*, 17 May, 1991, p. 912; and 6 April, 1990, p. 33). ATOC's transmitters were to be installed early this month on the ocean floor off the north coast of Kauai, Hawaii, and next month off Point Sur, California. Most receivers are already in place at 13 points around the Pacific Rim.

ATOC

Making noise. ATOC's undersea transmitters set off loud protests.

However, the level of opposition rose sharply in February after the experiment became a topic on Internet's marine mammal forum. By March it had spread to the national media and Congress, and before the month was out, the National Marine Fisheries Services (NMFS), which must issue a permit for the research, had announced it would delay its decision. The agency is seeking additional public and scientific comments, held hearings this week in Hawaii, and plans another in California.

The bureaucratic wrangling angers ATOC scientists, who have spent 3 years building and testing the advanced hardware. "The delay has not been based on any real facts," says oceanographer Walter Munk of Scripps Institution of Oceanography in San Diego, California, lead scientist for the project. "We were promised a date by NMFS, but now they have become worried about the public outcry."

But opponents say that the potential danger to the marine animals outweighs the value of the information about global warming to be gleaned by the underwater broadcasts. "There will be so many species affected—it's a complete gamble, a plunge into darkness," says biologist Lindy Weilgart, a postdoctoral fellow at Cornell University, who studies sperm whale vocalizations and who launched the debate on Internet.

At stake is whether researchers will be allowed to continue using sound to study the ocean's role in climate change and to determine if global warming is occurring. Heard Island was a one-shot test to establish feasibility; ATOC proposes to broadcast a 20-minute signal, initially six times a day, for 30 months in the Pacific basin. Within a year a sister project known as GAMOT, or Global Acoustic Mapping of Ocean Temperatures, plans to begin operating a system of technically advanced drifting broadcasters and receivers at sites not yet determined.

But ATOC is more than an oceanographic experiment. The project also plans to devote $2.9 million to biological studies. Whale biologist Christopher Clark of Cornell University will lead a team doing extensive population surveys of humpback whales in Hawaii and operating an "acoustic observatory" in California. Their efforts will help biologists gather data on how undersea sounds affect the long-term health and behavior of many species and may address such broader environmental concerns as the effect of low-frequency noise from shipping traffic on whale communication.

Such research could enrich a field that sorely lacks hard data. Last month's NRC report concluded that not enough is known to bolster the claims of either side. "People have very strong opinions about this, but we really have almost no information," says panel chair David M. Green, a psycho-acoustician at the University of Florida in Gainesville. Testifying last month at a public hearing, Robert White, the president of the National Academy of Engineering, said, "A permit should be expedited and granted for ATOC, while urging that essential research on the sensitivity of marine mammals to low-frequency sound be intensified."

Both sides recognize that large gaps in knowledge exist about the hearing ranges of many species and the depths to which the animals dive. But anatomical evidence and recorded vocalizations suggest that only a few species—blue whales, fin whales, and elephant seals—are potentially capable of detecting the ATOC transmission, says Darlene Ketten, an expert on marine mammal hearing at Harvard Medical School. Unlike the pressure waves generated by underwater explosions, she says, the low-frequency hum of the ATOC sound could not cause acoustic trauma or widespread deafening of these animals.

Anecdotal evidence from the Heard Island experiment doesn't support those concerned about the acute effects of the ATOC transmissions. A blue whale observed within 10 km of the sound source before, during, and after transmission showed mild responses, such as swimming in a new direction and changing how often it surfaced for air. Sperm whales within a radius of 70 km stopped clicking during the transmission, but resumed their vocalizing a few days later. But researchers say they still have much to learn. "What we don't know is the long-term implication of these kinds of subtle behavioral changes," says Ann E. Bowles, a biologist at the Hubbs–Sea World Research Institute in San Diego and a principal investigator on the Heard Island experiment. ATOC is a golden opportunity to answer such ques-

tions, says Bowles, who will participate in the marine mammal studies in Hawaii.

ATOC's sound source is expected to be much less intrusive than what was used for Heard Island. The loudness will be reduced 100-fold, from 214 to 195 decibels, and the sound will be broadcast at depths of 900 meters instead of 175 meters, where fewer animals are likely to swim. ATOC's slightly higher frequency—spread between 60 and 90 Hz, rather than at 60 Hz—should still be inaudible to most marine mammals. And the volume will be turned up gradually to give animals time to move away from the noise. Still, ATOC has the potential to affect many more animals and species than did Heard Island because the California site is located within the Monterey Bay National Marine Sanctuary, home to seals, otters, and toothed and baleen whales. ATOC leaders say they are prepared to turn off the transmitters if they appear to be harming the mammals.

Ironically, the dearth of data on the effects of noise on marine mammals has resulted in part from the policies of the NMFS, according to the NRC report. The Marine Mammal Protection Act prohibits the "harassment" of marine mammals, and the NMFS has used that clause to establish a Byzantine application process for scientific research permits that can take as long as a year. Revisions to the law now pending before Congress could shorten that wait, says an aide to Representative Gerry Studds (D–MA), chairman of the House Merchant Marine and Fisheries Committee, by requiring less information and a shorter turnaround time.

The irony of the government delaying ATOC because of scientific uncertainty while at the same time erecting obstacles to research that might clear up some of those questions was not lost on members of the NRC panel. "What worried me and other members of the committee," says panel member Peter Tyack of Woods Hole (Massachusetts) Oceanographic Institution, "is that we have such a profound ignorance of the impact of noise on marine mammals and the current regulations are actually impeding our understanding."

–Karen Schmidt

WOMEN IN SCIENCE

Disparities Detailed in NCI Division

Immunologist Sandra Smith-Gill had "a sense that something was amiss" in the way lab space, budgets, and personnel are divided among male and female investigators in her division of the National Cancer Institute (NCI). So 2 years ago, with the support of the division's scientific director Alan Rabson, she began examining how these resources are distributed and whether discrepancies in budget and personnel by gender have an impact on productivity. Smith-Gill's vague sense that something was amiss turned out to be depressingly correct.

Smith-Gill, with the help of Rabson's planning officers, surveyed the resources allocated to tenured researchers in the Division of Cancer Biology, Diagnosis, and Centers (DCBDC) for fiscal years 1991 and 1992. Her findings, detailed in an unreleased draft report now being circulated at NCI, are startling: Individual women researchers in the division, on average, received less than two-thirds the budgets allocated to their male counterparts at the same level of seniority.

The discrepancy at the top end of the scale is even greater: The largest budget allocated to a female researcher was less than half that of the man with the highest budget, even though the two have roughly the same length of experience. The report focused on 55 nonclinical senior investigators (11 women and 44 men) who are not laboratory or branch chiefs and plotted resources versus years since obtaining their Ph.D.s. Similar patterns of gender discrepancy show up in the allocation of research staff, with women receiving 63% of the personnel allocated to male researchers.

The report also found that in spite of recent concern about the status of women in science, these discrepancies haven't been declining. In fact, just the opposite is true: "During periods of budget growth," the report states, "the budgets of men have expanded proportionally more than those of women, widening the budget gaps between the genders; i.e., the rich got richer."

This skewed distribution of resources cannot be explained by differences in experience between male and female investigators. Women generally received fewer resources than men with the same level of experience. The budgets of women investigators, in fact, tend to cluster around $300,000, regardless of experience (see chart), while those of the men varied widely. "What surprised me is that the envelope for [the budget for] women is so much smaller than it is for men. There just isn't much scatter," says Smith-Gill.

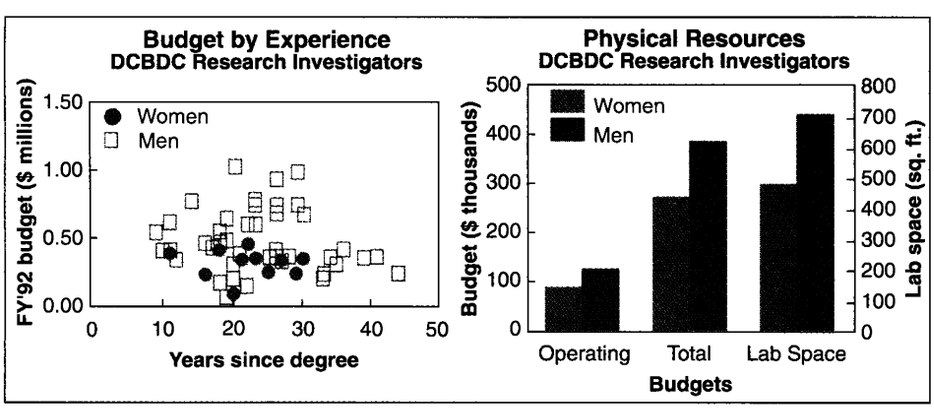
As for productivity, women investigators in the DCBDC published on average 54% as much as men. But that disparity disappeared when Smith-Gill divided researchers' total publications by the number of research personnel assigned to them. In other words, given the same resources, women will perform at least as well as men. The implication, says Smith-Gill, is that "women scientists are an underutilized resource at the National Cancer Institute."

Although still in draft form and offering few recommendations, the report is already having an impact in the DCBDC. Rabson, who says he "was a little surprised" by the findings, met with the division's laboratory chiefs and three of the division's senior women on 21 March to discuss the report. He says he expects to start addressing the resource discrepancy during the annual spring program review, which should start in a few weeks. "This year because of Sandy Smith-Gill's data we will be paying special attention to the status of women in the division," he says.

Smith-Gill is pleased that Rabson and the lab chiefs seem willing to address the problem, but she recognizes that the changes "will happen in small increments, not all at once." In the meantime, the women in the division are taking action on another front to improve their career prospects. They are organizing a mentoring system among the female researchers. "Women have to learn how to network," says Smith-Gill. "The responsibility is on us to do this."

Smith-Gill, who doubts that the disparities she identified are limited to the DCBDC, says she hopes other divisions and institutes will perform similar evaluations. That's one task women scientists will be eager to perform—if they are given the resources to do it.

–Lisa Seachrist



Glass ceiling. Women researchers get fewer resources, on average, compared with men *(right)*, and their budgets show little correlation with experience *(left)*.