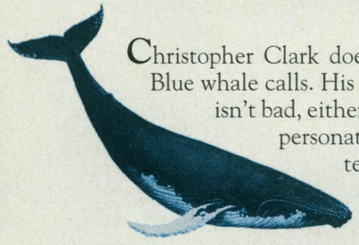
MARINE BIOLOGY

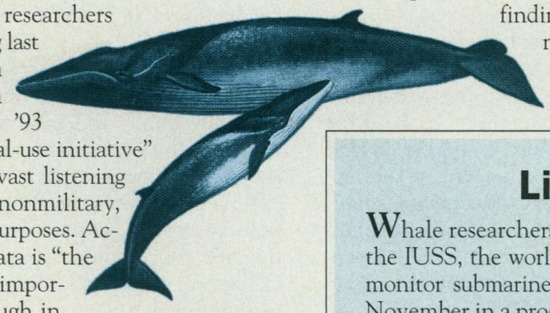
A Sub Surveillance Network Becomes a Window on Whales



Humpback whale

Christopher Clark does pretty good Blue whale calls. His finback whale isn't bad, either—and his impersonations have gotten a lot better over the past few months. You might call the improvement a peace dividend, because the Cornell University bioacoustics researcher is currently taking his whale-call cues from an enormous, previously inaccessible cache of data collected by the Navy's Integrated Undersea Surveillance System (IUSS), a network of underwater acoustic sensors and shore-based listening posts once dedicated exclusively to detecting enemy submarines.

Better whale impersonations, though, are among the smallest benefits of the data windfall that researchers began receiving last November in a Navy program called Whales '93—part of a "dual-use initiative" to tap IUSS's vast listening capability for nonmilitary, nonclassified purposes. Access to IUSS data is "the single most important breakthrough in whale studies ever," said Clark, who has been granted first crack at the data, at a 15 July briefing on the program for Navy officers and a handful of journalists at the Naval Research Laboratory (NRL) in Washington. With data from the Navy's hydrophone network, he said, "you're now a giant with enormous ears lying on the bottom... and you can hear the entire ocean." Researchers trying to puzzle out whale migration patterns, schooling behavior, and communication "have found the acoustic Rosetta stone for whales, and our task now is to decipher it."



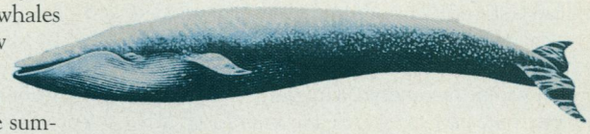
PHOTOS BY RICHARD ELLIS/PHOTO RESEARCHERS

Other researchers have more modest expectations for Whales '93, which, despite its title, will also funnel data to researchers studying underwater volcanoes and earthquakes (see box). Says whale researcher William Watkins of the Woods Hole Oceanographic Institution (WHOI), "It isn't a panacea," because not all whale behavior can be discerned from acoustic emissions and not all whale sounds are in the IUSS's specific low-frequency range. What the data will give whale researchers, says Watkins, is "the potential for basin-scale biology, so that you can know where a large population is, not just one animal on the side of your ship."

In the past, whale researchers were limited to statistics from commercial whaling operations, small research expeditions near whale-frequented coastlines, and occasional studies using boat-towed hydrophones or whale-tagging techniques. These methods, however, haven't been enough to give researchers a coherent picture of how whales behave in the open ocean and how they use their low-frequency vocalizations. "You know simple things like 'whales go north in the summer and south in winter,'" Clark says. But not "where whales are concentrated, how many individuals there are, and specifics about their lives," including what role their deep vocalizations play in navigating, finding food, and communicating.

Meanwhile, behind the cloak of secrecy, data that might have answered those questions was flowing from the Navy's sensor network into signal processing facilities, where submarine trackers watch and analyze visual versions of the signals called spectrograms. "If something makes noise in the water, we can hear it," boasts Captain Harold Williams, program director of the Undersea Surveillance Program Directorate of the Navy's Space and Naval Warfare Systems Command. For the past 40 years, though, "we really only paid attention to whales and earthquakes when they detracted from our ability to detect submarines," he says.

That doesn't mean scientists were never involved. Occasionally, the Navy called on bioacoustics experts like Clark and Watkins to help sort out whale calls from submarine noises. "At WHOI, we have tried to help the Navy out when they had sounds they couldn't figure out," says Watkins. But it didn't do science much good: Watkins and his colleagues were not permitted to publish what they learned. Whales '93, which the Navy intends to extend into the coming years, will allow nonmilitary researchers to



Listening to the Earth Move

Whale researchers aren't the only ones who stand to benefit from data gathered by the IUSS, the worldwide network of undersea acoustic sensors set up by the Navy to monitor submarines (see main story). Access to the data, partly declassified last November in a program called Whales '93, will be a boon for Earth scientists as well, predicts geophysicist Clyde Nishimura of the Naval Research Laboratory (NRL) and chief seismologist on the project.

In the past, seismologists trying to make sense of the pattern of undersea seismic activity have had to rely mostly on data from a few land-based sensors, Nishimura said at an NRL news briefing on 15 July. Now the Navy aims to let Earth scientists kibitz on the undersea clamor it has been monitoring for decades—and learn how much they've been missing. By way of example, Nishimura pointed out that in all of 1974, land-based sensors detected 37 earthquakes along the Mid-Atlantic Ridge, an undersea chain of volcanoes. The IUSS detected 84 events in a single week during the Whales '93 program, he said.

More important, he says, the system can monitor one kind of underwater seismic signal that has escaped land-based sensors: the so-called T-phase waves, which propagate mainly through water rather than the crust. Researchers have speculated that T-waves can provide an early warning of tsunamis, says Nishimura, but evidence has been scanty; Nishimura speculated that the IUSS may help resolve the controversy.

This sensitive ear on the ocean may also provide another kind of early warning—to scientists eager to watch undersea geologic processes unfold. As Nishimura was speaking at the NRL briefing, for example, researchers from the National Oceanic and Atmospheric Administration's Pacific Marine Environmental Laboratory were on a ship near the Juan de Fuca ridge, off the coast of Oregon and Washington. According to Nishimura, they were making "spectacular" observations of a massive undersea eruption. The oceanographers had been tipped off to the activity, said Nishimura, by an IUSS listening post in the Pacific that detected T-waves from the area.

–I.A.

visit a signal processing center set up at NRL to study IUSS data. Eventually, some data might be made available on tape, according to Navy officials—although they rule out distributing raw IUSS data. (Reliable submarine surveillance remains the primary mission of the IUSS.)

Even before more scientists get their hands on this data windfall, they are getting an early taste of what it may yield. At the briefing, Commander John Liechty, the Navy's project manager for Whales '93, flashed a striking view graph showing that an artificial sound source near Puerto Rico that had an intensity and frequency mimicking a finback whale vocalization could be detected 1000 miles away. Such data support a 20-year-old hypothesis that whales communicate over large stretches of ocean. Later, Clark added that data on finback whales near Iceland support the idea, first suggested by Watkins, that only some members of a migratory whale species take part in a particular migration.

To learn more, Clark and his Navy colleagues are honing their acoustic skills. Since last November, Clark and Readiness Officer Lieutenant George Gagnon, who has been tracking submarines for more than 20 years, have learned to distinguish five whale species, and, Gagnon says, even follow individual whales around the Atlantic. Blue whale calls look like "commas" amidst the TV static of the spectrograms, says Gagnon, who claims that he can pick out individual whales based on the precise shape and timing of their rumbling calls. Relying on that kind of signature, Gagnon says he tracked a whale, affectionately named Old Blue, for 43 days as it circled Bermuda, covering a total of 1450 miles.

Could that be a whaling yarn? Watkins is not convinced that individual discrimination is possible, though he admits that being able to follow individuals for weeks, without having to tag them, would be "a big thing" for marine mammal specialists. He is more optimistic about IUSS's ability to track whale populations over large areas. And that's exactly what Clark and his Navy collaborators are trying to do with data collected mostly between November 1992 and last May. At press time, Clark was slated to present early results at a meeting of the Animal Behavior Society, held this week at the University of California, Davis.

Among his early findings: Evidence that whales, like dolphins, use their vocalizations as sonar to form acoustic images of their ocean environment for navigation and feeding. Presumably, whales have had 35 million years of evolution to optimize that skill. If people could learn enough about how the whales manage their acoustic feats, perhaps they could pull off technological impersonations that would do more than just please audiences.

–Ivan Amato

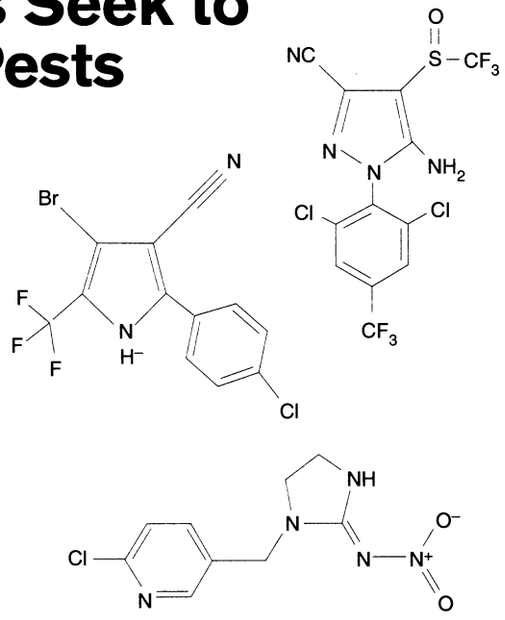
AGRICULTURE

New Chemicals Seek to Outwit Insect Pests

When it comes to insect pest control, most of the headlines these days go to research aimed at developing biological controls. Driven by the desire to protect the environment, there are many efforts afoot to use genetic engineering to create new plant strains with their own built-in insecticides, or to find bacteria, viruses, and other parasites that can keep a pestiferous insect in check with fewer of the problems that have been linked to chemical insecticides. But while these innovative forms of pest control have been grabbing all the attention, traditional chemical pesticides still dominate the world pesticide market: Their annual sales of more than $7 billion account for about 95% of the total. And those chemicals aren't standing still, since the chemical industry has been mounting its own efforts to develop new, more environmentally friendly insecticides.

Now, that work may be beginning to pay off. Three companies, two in Europe and one in the United States, that are in the vanguard of the research effort have either brought new insecticides to market or soon will. "There's some excitement at the moment because a number of companies have products different from the existing chemistries," says Allan Woodburn, an independent agrichemical consultant based in Edinburgh, Scotland. "If successfully commercialized, they would give a welcome boost to the chemical control of insects." They would also be the first chemical insecticides with novel modes of action to be introduced in nearly a decade, and those novel mechanisms are raising expectations that these chemical newcomers can alleviate a problem that has plagued the insecticide industry almost from its inception.

The problem is simply stated: Chemical insecticides frequently lose their effectiveness, because insects, among the most adaptable of creatures, develop resistance if repeatedly exposed. One classic example is DDT. When that much-maligned pesticide was introduced in the late 1940s, it virtually wiped out infestations of malaria-causing mosquitoes. But a few insects survived each exposure, eventually breeding resistant populations. And that's what makes it so attractive to have many different pesticides at hand, with varying mechanisms of action. Rotating pesticides with different modes of actions can limit the development of resistance, since the pest population can be fought with a second or third chemical before it builds up resistance to the first.



Benign control? From the top, Rhône-Poulenc's fipronil, American Cyanamid's pyrrole (active form), and Bayer's imidacloprid.

In addition, although chemical pesticides are a bugaboo of the environmental movement, the new insecticides may be safer for the environment than the older ones. "These new chemistries have greater specificity to a particular pest, [and therefore] less toxicity to nontarget species," says Phil Calderoni, an agrichemical specialist at SRI International, a research and consulting institute in Menlo Park, California.

The first of the new insecticides to reach market is imidacloprid, developed by the German chemical giant Bayer AG. The company has already introduced the chemical in France, Spain, Japan, and South Africa and expects that the Environmental Protection Agency (EPA) will give the go-ahead to begin selling it in the United States within a few weeks.

Bayer's development of imidacloprid illustrates the emerging trend in the pesticide industry away from trial and error and toward rational design of products based on a knowledge of insect biology. In this instance, the design process began with the knowledge that nicotine can kill insects. It's lethal because of its ability to bind to one type of receptor for the neurotransmitter acetylcholine, causing the insect's nerves to fire uncontrollably and leading to muscle paralysis. But nicotine itself cannot be used for insect control in the field because work done before 1950 showed that sunlight breaks it down very rapidly.

Two decades ago, researchers at Shell