TAUBES, GARY

ENDANGERED SPECIES

A Dubious Battle to Save the Kemp's Ridley Sea Turtle

In 1947 a Mexican engineer exploring a remote stretch of coast in northeastern Mexico filmed an extraordinary scene: Sea turtles were swarming ashore in waves that would carry 40,000 of them onto the tiny beach of Rancho Nuevo in the space of a single day. All were Kemp's ridley sea turtles, determined to propagate the next generation. But by 1987, as a result of 40 years of relentless poaching and shrimp trawling in the Gulf of Mexico, barely 500 of the 3-foot-long creatures were seen nesting during the course of an entire year.

It's a depressingly familiar story, but the Kemp's ridley isn't slipping quietly into oblivion. Since 1977, it has been the central figure in a strange saga of science, politics, and questionable heroics. Over the past 14 years, a federal project has spent more than $4 million airlifting thousands of eggs from Rancho Nuevo to the United States, painstakingly raising the hatchlings in a laboratory to protect them from predators during their first 9 months, and then releasing the young turtles to the open sea. Through the 1980s, keeping this program afloat also required battling the budget cutters of the Reagan Administration. But here's what the ridley rescuers have to show for a decade-and-a-half's conservation effort: Not one of the 18,000 "headstarted" turtles has been observed returning to any beach, anywhere, to nest. Critics are taking the outcome as confirmation of what they had suggested all along: After spending their first 9 months in a bucket, Kemp's ridleys may be ill-equipped to survive in the wild.

By now the project has drawn a remarkable list of detractors. Such major environmental groups as the World Wildlife Fund, the Environmental Defense Fund, Greenpeace, and Conservation International, together with sea turtle experts at the Fish and Wildlife Service (FWS), which coordinates the project, and the National Marine Fisheries Service (NMFS), which runs the project at its Galveston laboratory, have all turned against this desperate effort to save an endangered species. Indeed, the very man who initiated what is formally known as the Kemp's Ridley Headstart Project 14 years ago, biologist Jack Woody, national sea turtle coordinator for the FWS, has become its most outspoken critic.

You might think all that would be enough to doom any conservation program. But the Kemp's ridley project refuses to die. Just last November, after a 2-year struggle by Woody and other conservation biologists to kill the program, NMFS head William Fox gave it a new lease on life. Meanwhile, Gulf state congressmen have made efforts to expand it tenfold. Their constituents in the Gulf shrimp industry, it seems, would like to turn headstarting into a full-fledged turtle hatchery program to replace wild sea turtles killed in shrimp trawls, so that the shrimpers won't have to install devices to release turtles caught in their nets. Worse, the Galveston project, failure or not, has now become the model for other headstarting efforts being pursued by a host of nations, from Japan to Mexico, as well as the state government of Texas, which has called it "a proven management tool." Woody now says of his brainchild: "I've created a monster."

The project "is a success only if the numbers showing up from the artificial deal are greater than if you had left the turtles alone."

–Jack Woody

What went wrong, he and other critics of headstarting say, is that the project started with all of the uncertainties of a scientific experiment but none of the methodology. Nobody knew whether headstarting would increase the breeding population—and there was no way to tell. Project scientists admit they had no good means of marking turtles so they would be recognizable when—and if—they returned to shore to breed. As a result, researchers could not establish a control group of wild turtles to compare with the headstarted ones. The project's critics can stress the lack of positive results, but its supporters can just as easily argue the opposite: There's no evidence of failure. To Woody and others, their program is an object lesson in how bad science can take on a life of its own.

A bit of a ruse. Back in 1977, all Woody and his collaborators wanted was to protect the nesting beach at Rancho Nuevo from poachers; headstarting was something of a ruse to attract support for the effort. As Woody explains, "The Mexicans were trying to cover Rancho Nuevo with a couple of people. The job wasn't being done, and poachers had the run of the beach. We knew we had to get on that beach and help. The question was how do you justify spending taxpayer money, if you will, in a foreign country? What's the United States going to get out of it?"

The solution was to try and establish a second nesting beach on Padre Island, near Corpus Christi, Texas. In return for helping Mexico protect Rancho Nuevo, the United States would get 2000 ridleys eggs each year—3% of the total—to hatch on Padre Island. The hope was that the turtles born on Padre Island would eventually return there to nest, having imprinted as hatchlings on the "smell" of the sand—a process originally proposed by sea turtle expert Archie Carr of the University of Florida to explain why turtles return to their native beach. Once the hatchlings had imprinted, they would be taken to the Galveston laboratory for headstarting, to build up the new population quickly.

The yearly budget for imprinting and headstarting at Galveston would be between $250,000 to $500,000, and the project included an additional $25,000 toward Woody's primary goal of protecting the beach at Rancho Nuevo. In June 1978 the first 2000 eggs were airlifted to Padre Island, and the project, meant to run for 10 years, had begun. "It was started on guts and imagination," says Ed Klima, a marine scientist who is head of the Galveston laboratory. "From that time, we've gone ahead, good or bad."

Early on, the Galveston lab faced painful lessons about raising ridleys in captivity, which was then an unknown art. The first lesson was that ridleys are extremely aggressive, which is to say Galveston lost large numbers of hatchlings by rearing them together; the "deaths [were] caused by biting and also indirectly by infection," explains Charles Caillouet, one of the project's head scientists. So the workers isolated the turtles in buckets. Then the hatchlings succumbed to fungal diseases, which the Galveston scientists eventually learned could be avoided by keeping the water warm.

Then there was the problem with sex. In 1978, it was only a suspicion that the sex of a turtle might be dependent on the temperature at which the eggs were incubated. By 1983, the curious fact that cooler temperatures yielded mostly male hatchlings and warmer temperatures mostly females was unavoidable, but how did one find out what temperature tipped the balance? It was impossible to sex a hatchling without killing it, and no one was ready to allow that. Finally, by 1985, the Park Service on Padre Island calculated that 31 degrees Celsius was the pivotal temperature. Now the lab says that only one-third of the hatchlings born before

1985 were female, while critics of the program say there is no way to know. All the early hatchlings may have been male.

Added to all that were the embarrassing mistakes of a new and unprecedented program: a 1983 release of "yearlings" off Padre Island in sargassum weed; 69 of them washed ashore dead within 2 weeks. A 1983 shipment of 2000 eggs to Padre Island that was left in an air-conditioned room; only one in eight hatched. A 1986 release of 519 turtles in Copano and Nueces Bays, near Corpus Christi, under the mistaken assumption that no shrimp trawlers would be working the area; as many as 65 were caught in the nets or washed up, injured or dead, on shore. "That was a disaster," says Woody. "They were assured that the shrimping season was closed, and it wasn't."

The blunders were obvious enough, but there was that deeper problem: Would scientists be able to tell if the program was working? As early as 1980, University of Toronto biologist Nicholas Mrosovsky, editor of the *Marine Turtle Newsletter*, suggested that no one had yet formulated "what would constitute evidence that [headstarting] is useful as a conservation procedure." The Galveston workers did crimp tags onto the flippers of their charges before releasing them, but Mrosovsky observed that a tag placed on a 9-month-old turtle was not likely to stay on for the decade or more it took the turtle to reach reproductive age. Moreover, wild turtles were not being tagged in comparable numbers to create a control group—and because the wild turtles had to be tagged as hatchlings, the tags were even more likely to be "sloughed off or incorporated as the animals grow," Mrosovsky noted. In his 1983 book, *Conserving Sea Turtles*, Mrosovsky pointed out that headstarting was "a remarkable kind of gamble, one we may never know if we have won or lost."

PHOTO RESEARCHERS

Uncertain future. A Kemp's ridley hatchling heads out to sea.

Where do all the turtles go? As evidence that headstarted turtles do live to maturity, at least occasionally, the Galveston laboratory has cited three older turtles, still carrying their tags, that were found stranded as far afield as the beaches of Morocco and France. On the other hand, no ridleys had ever been documented before in these areas. "A turtle that survives and ends up in a place where it shouldn't be," says Tundi Agardy, a conservation scientist for the World Wildlife Fund, "might as well be dead..." From time to time, immature headstarted turtles were captured. But many of those were taken by swimmers whom the turtles had meekly approached, something that never happened with wild ridleys.

None of this evidence was very convincing to scientists within the Galveston program, who prepared a report saying that the long-term survival of headstarted turtles was probably, as Woody puts it, "zilch." The report was never released, and one NMFS employee said it was suppressed. "I'm sure you understand," the researcher says, insisting on anonymity, "that endangered species recovery and biology is a highly politicized arena."

"It was started on guts and imagination. From that time we've gone ahead, good and bad."

–Ed Klima

That was becoming especially true of sea turtle headstarting, which was acquiring a powerful constituency. Part of it consisted of Gulf shrimp fishermen—the most devastating source of mortality for the ridleys. One 1987 study concluded that shrimp trawlers accounted for 11,000 sea turtle deaths each year, perhaps 500 or more of them being ridleys. (A 1990 National Research Council study suggested this number was low by a factor of four.) To spare the turtles, NMFS spent $2,000,000 between 1978 and 1984 working with shrimpers to develop Turtle Exclusion Devices (TEDs)—in essence, escape-hatches in the trawl nets that release captured turtles while retaining the shrimp. As the shrimpers came under pressure to use TEDs, however, they claimed the devices significantly reduced their catch, caused their nets to tangle and tear, and lowered their trawling time. In lieu of using TEDs, shrimpers insisted, they would be glad to pay to restock the Gulf with baby turtles, raised in programs like that of the Galveston lab.

Another champion of the Galveston program was Carole Allen and her fellow conservationists at HEART—Help Endangered Animals-Ridley Turtles. Allen founded HEART in Houston in 1982 as a small nonprofit organization to support the Galveston headstarting program. HEART's rite of passage came that same year, when NMFS decided to mothball the Galveston lab in response to Reagan Administration budget cuts. Allen rallied her group in a letter-writing campaign, saved the lab, and from then on was poised, as one NMFS employee phrased it, to "raise the roof" over any attempts to discontinue the headstarting project.

These supporters collided with the doubters, rallied by Woody, beginning in October 1988, when the headstarting and imprinting programs had run their proposed 10-year course. The Kemp's Ridley Working Group—NMFS, FWS, the Park Service, which was running the Padre Island end of the project, and the Mexican Instituto Nacional de Pesca—met in Albuquerque, and, at Woody's prompting, agreed to suspend both the headstarting and imprinting projects. The programs would be reduced to 1000 eggs in 1989 and zero in 1990. Woody hoped that NMFS would then redirect its resources to proven conservation measures, such as finding and protecting every Kemp's ridley nest in Mexico and learning everything possible about where the wild ridleys went after they left the beach as hatchlings.

Experiment without end. Before the decision could be passed up the ladder, though, NMFS assigned a "blue ribbon" panel of turtle experts to evaluate the Galveston program. To critics of headstarting, the panel had "a curious makeup," as Woody puts it. Thane Wibbels of the University of Texas at Austin, the head of the panel, had worked for 2 years (1982-83) on the Galveston headstarting project while obtaining his master's degree. Three of the other scientists on the five-member panel—Mark Grassman of Memphis State University, John Hendrickson of the University of Arizona, and Peter Pritchard of the Florida Audubon Society—were also longtime advocates of headstarting. The panelists spent 2 days at the lab in August 1989 and recommended that the headstarting continue for 10 years, following the implementation of TED regulations in the Gulf.

The fifth member of the panel, Nat Frazer of Mercer University in Macon, Georgia, later wrote a paper for *Conservation Biology* (in

press) that could be considered his minority opinion. Frazer objected to headstarting on the grounds that it does nothing to address the primary causes of sea turtle mortality, while at the same time serving "as an attempt to relieve humans of the consequences of our actions. We may feel a little freer to degrade the habitat and over-harvest turtles either intentionally or incidentally if we have headstarting programs in place."

Thane Wibbles

Even the other panelists, though, found they could hardly give headstarting a ringing endorsement. In their consensus report, they conceded that headstarting had failed as a conservation measure: "Tag return, stranding, trawling, and nesting beach data recorded by NMFS, U.S. Fish and Wildlife Service, and the Instituto Nacional de Pesca collectively indicate that the mortality rate of Kemp's ridleys in the wild (both headstarted and nonheadstarted) is so high that few if any headstarted ridleys are likely to reach sexual maturity."

The bottom line, Wibbels later told *Science*, "was that this wasn't a successful program." Still, he says, the panel had been specifically directed not to "look at sea turtle conservation as a whole." As an experiment, he says, the program was still worth continuing: Once the turtles were protected from the shrimpers, he and his colleagues reasoned, the Galveston program would offer "the best chance ever to answer the question [of whether headstarting is an effective conservation measure]."

Turtle hatcheries. Headstarting not only had a new lease on life, it was threatening to expand dramatically. In the summer and fall of 1989, representatives of three shrimping states along the Gulf—Billy Tauzin of Louisiana, Gene Taylor of Mississippi, and Solomon Ortiz of Texas—introduced two turtle "stocking" bills before Congress. The first would have amended the Endangered Species Act, authorizing the secretary of the interior to make grants for projects for the propagation of endangered species by programs such as headstarting; the second would have established a headstarting program specifically for threatened and endangered turtles, to which as much as $2,750,000 would be earmarked yearly for construction and operating expenses—a tenfold expansion of the Galveston program.

Both bills died in committee, but they helped secure the future of the Galveston program last November. That was when NMFS's Southwest Fisheries Center sided with Woody and officially recommended that the program be phased out, and the decision was promptly overruled by NMFS head Fox. Besides citing the blue ribbon panel report, Fox argued that killing the experiment might result in a renewed, and perhaps successful, effort by the congressional supporters of the shrimping industry to authorize massive direct funding of turtle stocking programs. Fox did agree, however, to a review of the program if new evidence arises arguing against it.

The danger, say Woody and other sea turtle experts, is that such evidence may never materialize. Headstarting advocates are pinning their hopes on new tagging methods, which they say will give them a better chance of recognizing headstarted turtles if and when they return to breed. But Woody stresses that there is still no comparable way to tag the control group, the palm-sized hatchlings. The project is "a success only if the numbers showing up from the artificial deal are greater than if you had left [the turtles] alone," he says. "And we don't know. It will never be measurable."

Woody says he has learned one clear lesson from his 14-year experience with headstarting. Even a crash program to save a species should be designed so its success can be judged. "That's the first question you have to ask yourself before you go in and spend millions and millions of dollars that are pretty damn scarce."

–Gary Taubes

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TECHNOLOGY

Virtual Acoustics Puts Sound in its Place

Think of how catching snippets of several different cocktail party conversations gets easier when the conversations are taking place on opposite sides of you. Or recall how the sound of footsteps behind you on a dark street commands your full attention, while the same sound coming from the other side of the street is easy to ignore. Our brains, it seems, rely on direction to untangle sounds and make sense of them.

Taking their cues from such real-life examples, a small group of psychologists, acoustic scientists, and engineers are applying the power of computers to turn the sound heard over headphones into a three-dimensional acoustic world. The technology, called virtual acoustics, is far more than an upscale version of a stereo headset. Whereas stereo sounds come from the same side of your headset whichever way you turn, the sounds of virtual acoustics seem to come from fixed points in the outside world: Turn your head to the right, and a sound that seemed to come from the left is now behind you. That kind of acoustic realism could improve the performance of anyone responding to sound on a headset.

Air traffic controllers and pilots, for example, have to match up voices in the cacophony coming over their headphones with the positions of airplanes visible from the tower or cockpit or on a radar screen. By giving each voice a direction matching that of the real plane, virtual acoustics could speed their response. It could also yield new audio navigation aids for the blind and even bolster the realism of the synthesized sounds in video games. Says Elizabeth Wenzel, a psychologist at the NASA Ames Research Center in Mountain View, California, who is studying the technology, virtual acoustics "is going to be very useful for any sort of task that's three-dimensional by nature."

The potential has sparked a lively research program, taking place at NASA Ames, the University of Wisconsin, and several other institutions. Some of the work is aimed at adding an acoustic dimension to the computer-generated visual environments known as virtual realities (*Science*, 3 April, p. 45). But more and more of this research is independent of the largely visual virtual reality simulations that have lately had so much attention. For one thing, virtual acoustics entails distinctive research challenges, which center on the psychology of how humans perceive sounds.

The ingredients of virtual acoustics are a set of sounds to be processed, headphones for the listener, and a package of computer hardware and software that alters the sound going to each ear to create the illusion of a specific direction. So that the system can keep the apparent direction of the sound constant when the listener turns, it tracks the orientation of the listener's head with the help of a magnetic device mounted atop the headphones. So far, such setups do a good job of accurately positioning synthesized tones, clicks, and noise bursts—at least for some listeners. But others perceive the sounds as coming from inside their heads rather than from the external environment. And these simulated sounds have been notably lacking in realism because they omit the rich blend of reflections, damping, and filtering that is typical of real-life sounds.

The key challenge in improving these results, say investigators, isn't building more sophisticated headphones or adding computer muscle. Instead, it lies in understanding and reproducing the sonic cues by which listeners pinpoint a sound's direction. On the simplest level, a sound coming from the left reaches the left ear a little earlier—and is also a little louder on the left. But sound waves hitting the outer ear are also modified by its curves and folds in