are working to understand why increasing the viscosity (or resistance to flow) of a food makes it seem less flavorful, even though experiments indicate that viscosity has no effect on the amount of aroma that gets into the nose. Edmund Rolls, a neuroscientist at Oxford University, and his colleagues showed in 1999 that neurons in the brains of macaque monkeys respond to the texture of fat in the mouth—particularly to liquid fat such as cream and liquefied chocolate-hazelnut spread—independently of neurons clued in to smell or taste. The tip-off was that neurons responded just as much when the monkeys were fed harmless amounts of silicone oil, which has a fatlike texture but no taste or smell. Because humans and macaques have evolved to savor fat, and because the monkeys were more readily sated by liquid fat than by solid, Rolls hypothesizes that taking fat as a liquid, or chewing foods well to liquefy the fat in them, may have application in weight control.

The science of texture, like that of food generally, is a subtle and sophisticated one. But "to understand texture you have to be eclectic," says Parker, "because you do not know in advance if the answers to the questions you ask are in the *Journal of Neuroscience* or *The Physics of Sliding Friction*." The scientists hope that meeting challenges like this will help move the science of food off the back burner. **–GISELLE WEISS**

Giselle Weiss is a science writer based in Basel, Switzerland.

MARINE MAMMALS

Scientists Use Strandings To Bring Species to Life

Some scientists worry that eye-catching efforts to rescue stranded marine mammals may detract from less glamorous—and smellier—research

ASSATEAGUE ISLAND, VIRGINIA—The baby whale wasn't fast enough to escape the ship's giant propeller. With its backbone shattered and blood streaming from five deep gashes on its right flank, it was dead within minutes.

Robert Bonde, a marine mammal researcher with the U.S. Geological Survey in Gainesville, Florida, didn't witness that marine hit-and-run earlier this year. But the anatomist had little trouble reconstructing the last moments in the life of the 8-meter-long northern right whale, now a rotting carcass here on an isolated beach. "It looks like the ship caught him from behind, just as he put his head down to dive," Bonde concluded after examining clues provided by the size, depth, and location of the slashes.

Bonde and his colleagues have spent decades trying to better understand the lives—and deaths—of seagoing mammals by examining the thousands of whales, dolphins, seals, sea lions, and manatees that wash up on shore each year (see table). Most don't survive: Live animals account for less than one-fourth of the 3000 reported in an average year in the United States. And most are dead for days before they're found, leaving researchers to dub their work "stinky science."

Still, the knowledge acquired from beached animals is fueling moves to beef up stranding science in the United States and elsewhere. Responding in part to the need for more information about endangered species such as the right whale, Congress last year approved a plan to give up to $15 million over the next 3 years to the 25-year-old U.S. stranding network, a sometimes uneasy alliance of about 400 private research institutions, independent wildlife rescuers, and government agencies. And beachcombing scientists around the world are discussing ways to improve international collaboration.

The growing interest in stranding work, however, is dogged by debate. Some researchers and animal-welfare advocates want to pull out all the stops to rehabilitate and release the animals back into the wild—at upward of $1 million for a large whale. But others say that it's often more humane—and more fiscally prudent—to euthanize some of the victims and invest more in the mundane job of analyzing the samples that are harvested. The tension underscores the "uniquely difficult role" played by groups that respond to strandings, says wildlife veterinarian Andrew Stamper of Disney's Living Seas pavilion in Orlando, Florida: "They must be both a humane society dealing with the welfare of stranded animals and an objective institution collecting scientific data."

Whale tale. Researchers Scott Kraus (*left*) and Robert Bonde (*right*) prepare to necropsy a stranded right whale killed in a collision with a ship.

Carrion hunt

At least since Aristotle pondered why dolphins would wash up along ancient Mediterranean shores, humans have been interested in stranded marine mammals. But the systematic study of strandings didn't really begin until the early 1970s, when governments began outlawing whaling and giving new legal protections to all marine mammals. The changes sparked U.S. efforts to collect stranded animals and use the specimens to learn about wild populations.

REPORTED STRANDINGS ALONG THE U.S. COAST, 1994–98

Region	Whales/dolphins	Seals/sea lions
Maine to Virginia	1013	1768
Carolina to Texas	3683	44
California	624	10,147
Pacific Northwest	119	1098
Alaska	462	172
Total	**5901**	**13,229**

CREDITS: (LEFT TO RIGHT) D. MALAKOFF; SOURCE: NATIONAL MARINE FISHERIES SERVICE

Cutting-edge science. Tissue samples can help stranding researchers determine everything from a whale's cause of death to its family tree.

CREDIT: D. MALAKOFF

"We didn't know much about the distribution or life history of most marine mammals," recalls James Mead of the Smithsonian Institution's National Museum of Natural History in Washington, D.C. In 1972, he and a colleague, Charles Potter, began journeying to beaches within a day's drive of the museum. They could cover a lot of ground: "We were young, so a day's drive really meant 24 hours," says Mead, now 58.

Up the coast, veterinarian and oceanographer Joseph Geraci was doing similar work for the New England Aquarium in Boston. Like Mead and Potter, Geraci encouraged local officials to alert him to beached animals. Such efforts led to the current stranding response network managed by the National Marine Fisheries Service (NMFS), which funnels reports to groups with the personnel and permits to handle the animals.

In the early days, cutting up beached animals "was not regarded as science," says Geraci, who recalls colleagues teasing him about his "relentless search for carrion." But a 1973 mass stranding of white-sided dolphins on a Maine beach highlighted the scientific bounty awaiting those willing to truck the specimens to a freezer and then dissect them. Working with a small army of students, Geraci piled up discoveries about dolphin anatomy, diseases, and physiology.

Over the years, researchers have used the locations, dates, and details of hundreds of strandings to piece together a surprisingly detailed portrait of white-sided dolphin life. Measuring fetuses from stranded females, for instance, provided scientists with insights into gestation length, breeding seasons, and growth rates—details that can be crucial to government biologists charged with protecting the species. "The life history of the white-sided dolphin is known almost exclusively from stranding data," says Geraci, now at the National Aquarium in Baltimore, Maryland. Another 10 species of whales and dolphins—out of some 80—are known only from a handful of stranded specimens, notes Mead, who recalls spending the night on a beach in Argentina guarding the carcass of a particularly rare beaked whale so it wouldn't wash out with the tide. "I was so excited I couldn't sleep," he says.

In recent years, such specimens have helped researchers probe a host of biological mysteries, from why animals strand (see sidebar) to how mammals adapted to life in the sea. For instance, over the last decade, three researchers—Sentiel "Butch" Rommel of the Florida Marine Research Institute in St. Petersburg and Ann Pabst and William McLellan of the University of North Carolina, Wilmington—have led efforts to piece together one particularly interesting puzzle: how dolphins, seals, and manatees regulate their body heat, keeping it high enough to survive in the cold ocean but low enough to preserve fragile sperm and developing fetuses. The answer is a remarkable heat-exchange system that allows the animals to vary the temperatures of different organs.

Animals hauled from beaches also help researchers track the toll from disease and human activities. The carcass of the 3-month-old right whale found in Assateague, for instance, documents the threat from ships, while other beachings have highlighted problems caused by fishing gear entanglement or plastic trash eaten by mistake. One study of 6200 California sea lions that stranded between 1986 and 1998 found that nearly 8% showed evidence of such "human interactions"—often gunshot wounds, presumably from fishers upset by the competition for fish. Other studies of tissue samples taken from beached animals helped document the spread of pesticides and industrial chemicals into the global food chain—including whales and seals that spend much of their lives in remote polar regions.

In 1998, Frances Gulland of the Marine Mammal Center in Sausalito, California, helped solve the mysterious deaths of hundreds of California sea lions along the Pacific Coast. By analyzing stomach contents, studying toxicology reports, and sampling offshore algal blooms, Gulland and other researchers realized that the sea lions had dined on herring that had in turn fed on a well-known alga, *Pseudo-nitzschia australis*, which produces domoic acid, a potent neurotoxin. Because domoic acid also poses a serious threat to human seafood lovers, state officials quickly banned shellfish harvesting and fishing in affected areas. The sea lion deaths, notes Gulland, served as a "very effective early warning system in protecting human health."

Smelly science

Most strandings aren't as well publicized as the sea lion die-off. And the work is hardly glamorous: The young right whale at Assateague had been killed 4 or 5 days before it was spotted on 17 March by park rangers, and it emitted the ripe aroma of spoiled meat by the time researchers gathered 2 days later. Nearly every stranding veteran has at least one tale of being banned from an eatery or motel due to the deathly stench clinging to their body and clothes. "A gas station attendant once told me just to leave the money on the pump," recalls Rommel.

Besides enduring the smell, stranding researchers must be adept at all types of equipment. Smaller seals and dolphins can be necropsied—the animal equivalent of an autopsy—with traditional surgical tools. But the larger whales, up to 25 meters long and

Why Do Marine Mammals Strand?

Although many strandings end up as unsolved cases, scientists have no shortage of suspected causes. Post-mortems indicate that many beached animals are diseased or malnourished due to age, injury, or changing ocean conditions. Others have been poisoned by toxic algal blooms or injured by fishing nets, boats, or predators such as sharks or killer whales. Sometimes, big storms or unusually strong tides may disorient the animals, particularly in shallow coastal waters. And some studies suggest that parasites might disable an animal's ability to navigate by disrupting sensory organs such as ears.

It's been harder, however, to pinpoint the causes of relatively rare mass strandings, which can involve dozens of seemingly healthy animals. One factor may be the strong social bonds forged by some species, such as bottlenose dolphins and pilot whales. Some researchers speculate that healthy animals may follow a sick leader or parent into danger, unable to break their allegiance. Others wonder whether the animals may be disabled by a growing load of chemical pollutants, such as pesticides, found in their tissues. Most scientists are skeptical, however, about another theory, which brands beached marine mammals as suicidal. **–D.M.**

weighing dozens of tons, require giant scythelike flensing blades for stripping away blubber and bulldozers and trucks to move body parts. "It's pretty ungainly science," says Rommel, who once "nearly drowned" when he slipped through a hole in the skin into the mushy guts of a large fin whale.

Sometimes the dead refuse to give up their stories. Reports that the baby right whale's body was in prime condition, for instance, had prompted anatomist Darlene Ketten of the Woods Hole Oceanographic Institution in Massachusetts to board a dawn flight in hopes of extracting the animal's ears for her studies of marine mammal hearing. But she discovered that time and the churning action of the waves had reduced the corpse's insides to a gray soup and dislodged the ears, reducing their scientific value.

Even so, Ketten, Bonde, and researchers from the Virginia Marine Science Museum in Virginia Beach, the local stranding coordinator, filled enough vials and baggies with tissue samples to help researchers. Some are assembling a family tree of the 300 or so remaining northern right whales, using DNA extracted from the samples. Others hope to identify pollutants that are transferred from mother to calf by way of breast milk.

Beach battles

Because the right whale is a highly endangered species, NMFS paid part of the cost of responding to the Assateague Island stranding. But its stranding budget of less than $1 million doesn't go far. Most stranding groups stay afloat by relying on volunteers—from academics to laypeople.

Florida has come up with a novel way to pay the freight: the sale of special license plates that promote conservation of the endangered manatee. The widely envied arrangement produces enough revenue to pay for detailed necropsies on more than 300 sea cows a year. Public outreach is another source of income. A handful of aquariums, private zoos, and wildlife groups that specialize in rehabilitating live stranded animals raise $200,000 or more a year by highlighting efforts to nurse beached animals, usually seals and sea lions, back to health. The work is painstaking, involving everything from hourly bottle feedings to exhausting daily workouts to rebuild injured muscles.

Such rescue efforts, however, are a source of tension between animal-welfare advocates, who emphasize saving the animals, and researchers, who say that sometimes euthanasia—usually by lethal injection—is the better option. "These are emotionally charged settings," says one stranding veteran. "I've seen shouting matches and fistfights, people tugging on both ends of a pilot whale, and kids throwing themselves in front of a hypodermic needle."

To cool the passions, NMFS officials have drafted guidelines on when to attempt a rescue and which rehabilitated animals should be allowed back into the wild. The agency must "confront a profound ethical and practical question," says Kraus. "Are we defying natural selection by putting back animals that shouldn't be in the gene pool?" No one knows, for instance, how many refloated animals actually survive. Kraus says that according to unpublished data collected by the New England Aquarium, for instance, about half of the seals it has rehabilitated over the last few years died within a few months of release.

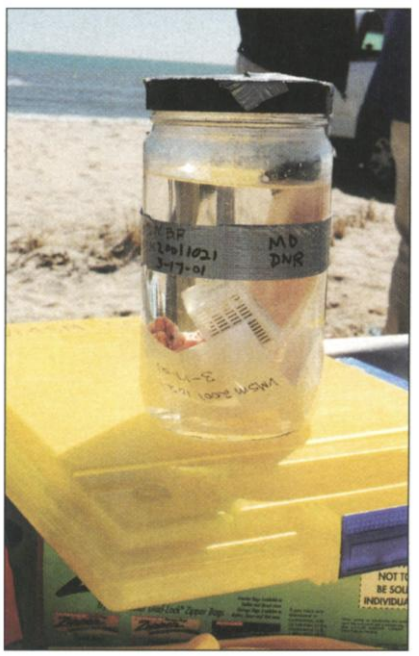
Even animals that make it to rehabilitation centers pose risks. Rescued whales and dolphins have spread fatal viruses to captive animals. And some researchers worry that the patients, if released, could spread new strains to wild populations.

Some rescue advocates argue that such risks have to be weighed against what we can learn from rehabilitated animals—and their value as vehicles for public education. "Rehabilitated animals have taught us a lot about behavior and physiology ... and helped make the case for marine mammal protection," notes Sharon Young, a Cape Cod, Massachusetts–based consultant to the Humane Society of the United States. Rehabilitated dolphins, for instance, have played key roles in studies of cetacean intelligence, communication, and hearing. And satellite tags attached to released animals have also provided new insights into the animals' travels, she says, revealing that they sometimes take trips of unusual length to unexpected destinations. Young says that stranding groups "should start with the notion that you are going to try to save [beached animals]" and make euthanasia a last option.

Money talk

The tension surrounding rescues has helped spark debate over how NMFS should allocate the new fund—a total of $4 million this year in grants of up to $100,000—that Congress wants to pump into the U.S. stranding network. NMFS officials and some marine mammal scientists have cautioned against spending too much on rescue and rehabilitation, which can cost $50,000 per seal or sea lion and double that per whale. In one well-publicized case, Sea World entertainment park in San Diego, California, spent more than $1 million to rear and release a single baby gray whale found on a beach in 1997. Its fate is unknown, in part because a tracking tag fell off the animal shortly after release.

"Most of the network recognizes the valuable information you can get from dead animals and the severe financial drain created by [caring for] live animals," says NMFS's Teri Rowles, who leads the program and is sifting through public comments on this summer's draft. But outsiders say the strong public interest in rehabilitation virtually assures that some of the money, to be handed out starting later this year, will go to rescues. In the meantime, Rowles and her staff are developing a Web-based tracking system to keep tabs on U.S. stranding events and working to beef up the several tissue banks it helps fund.



Ready for study. Some samples will go into government tissue banks for genetics and pollution studies.

Rowles is also involved in discussions with other nations that have stranding networks, notably New Zealand and the Netherlands, as well as those, such as Japan and Taiwan, starting to build them. The long-range goal is a data-sharing system that will allow researchers to spot large-scale patterns that might point to major ecosystem changes, such as increases in harmful algal blooms or climate shifts. For the moment, however, the focus is on solving existing puzzles. Gulland, for instance, is one of many researchers trying to understand the causes behind a recent spike in the number of gray whale strandings along the West Coast. Some believe it is a healthy sign that the threatened species has rebounded to fill its ecological niche and that the animals washing ashore had died naturally. Others worry that the beachings foreshadow an onslaught of pollution or disease. Whatever the cause, the episode points to the continuing attraction of marine mammals in death as in life.

–DAVID MALAKOFF

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