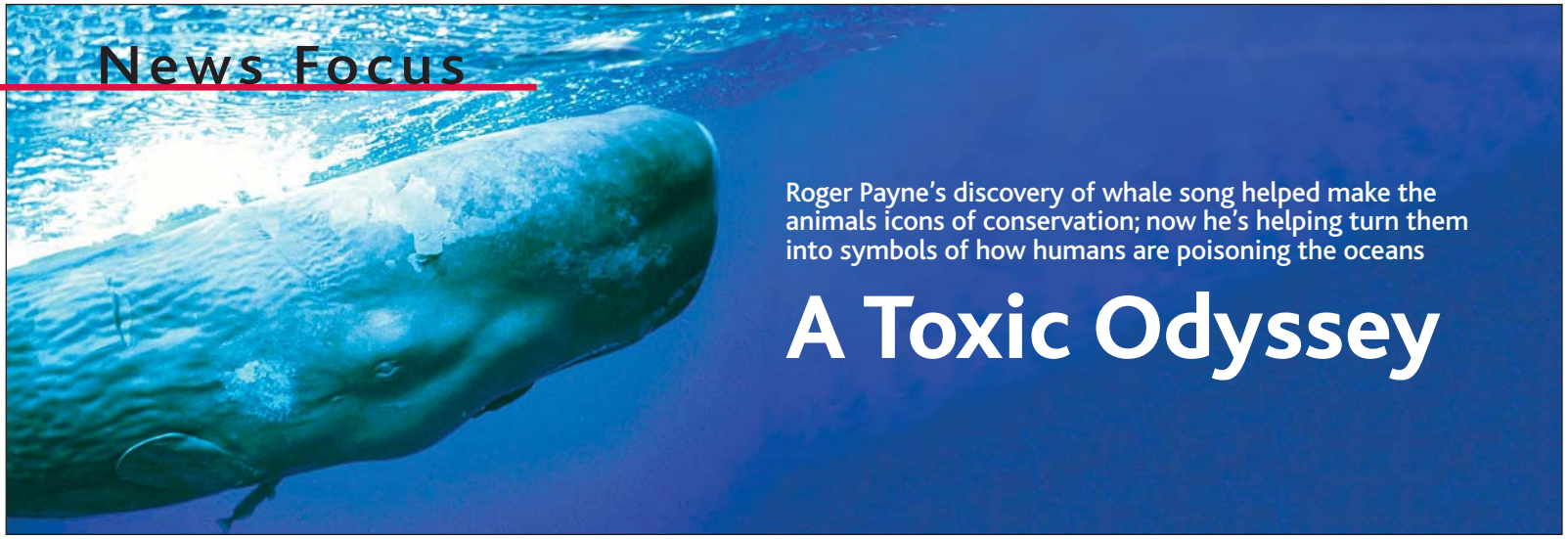


Roger Payne's discovery of whale song helped make the animals icons of conservation; now he's helping turn them into symbols of how humans are poisoning the oceans

A Toxic Odyssey

THE INDIAN OCEAN, 2°N, 72°E—Seven days have rolled by without a sighting. Although the waters over these deep ocean trenches east of the Maldives are a well-known feeding ground for sperm whales, the crew of the *Odyssey* has seen nothing larger than a pod of playful dolphins, riding the ship's bow wave and flinging themselves into the air like Chinese acrobats. A man with silver flyaway hair steps out from the pilothouse and squints up at the observation deck, where two crew members are scanning the horizon. "A gold doubloon for the first man to spot a whale!" he booms, imitating Captain Ahab from *Moby-Dick*.

Like Ahab, Roger Payne has been plying the seas in a tireless search for sperm whales, the largest of the toothed whales. Unlike Ahab's ship the *Pequod*, however, the *Odyssey* is equipped with tissue-sampling crossbows instead of harpoons and a toxicology lab instead of blubber-boiling tryworks.

Payne is best known for revealing that the unearthly vocalizations of humpback whales are structured like songs, a discovery that made the cover of *Science* in 1971 (16 August), and for his hypothesis that the sounds of fin and blue whales carry information clear across the oceans. But the focus of his research out here is pollution—specifically, the class of humanmade chemicals known as persistent organic pollutants (POPs), which can sabotage biochemical processes by mimicking hormones. Some scientists fear that these compounds would become so concentrated in marine ecosystems that fish stocks would be rendered too toxic for human consumption. "No one knows how polluted the oceans are," says Payne, "because no systematic, global study has been made."

To try to plug that gap, Payne has assembled a 12-person crew of scientists and educators to circumnavigate the globe for 5 years aboard the *Odyssey*, a 28-meter floating laboratory. Because POPs become increasingly concentrated at higher levels of the food chain, Payne's strategy for determining the extent of pollution is to measure contamination in the blubber of sperm whales—a top predator found in all oceans. After 4 years at sea, his team's early results are looking grim: The chemicals have accumulated in the fat of every sample analyzed so far, even from places farther from land than anywhere else on Earth. The presence of POPs, particularly in coastal environments, has long been known, says John Stegeman, a toxicologist at the Woods Hole Oceanographic Institution in Massachusetts, but Payne's study is crucial because it will provide a global snapshot of the extent of contamination.

To take such samples, of course, the intrepid researchers must first find whales. After this unusually long hiatus of 7 days staring down the blue rim of the horizon, the crew is getting antsy. But just when it seems that all the whales have fled for the poles, the hydrophone speakers erupt with clicks. "We've got whales!" says Payne with a grin. The glowing dots on the computer screen show a group of 20 sperm whales feeding just ahead. Bowls of cereal and cups of coffee are left half-full as the crew springs into action and the *Odyssey* surges forward.

No ordinary whaler. The *Odyssey* is in the last year of a 5-year voyage to measure persistent organic pollutants in sperm whale blubber.

A life among whales

For Payne, this voyage is part of a personal odyssey that began exactly 50 years ago when, as a "green" Harvard freshman, he was asked to baby-sit some bats. These were the furry research subjects of the late Donald Griffin, the renowned biologist who discovered echolocation. Up to this point, Payne says he "had no idea you could make a living doing something like biology." After Griffin became his undergraduate research mentor, Payne became "obsessed" with bioacoustics. He went on to do his Ph.D. research on how owls use sound to locate prey, and during his postdoc he showed how moths use sound to evade predators. "The secret of Roger's success," says Thomas Eisner, an entomologist at Cornell University in Ithaca, New York, who helped supervise Payne's Ph.D., "is his creative, playful mind and infectious passion." Eisner recalls Payne constantly zipping around campus on his bicycle wearing a cape and a cello on his back.

Then, Griffin called on Payne once again. Griffin had moved to Rockefeller University in New York City, and he persuaded Payne to join him there to pursue something new. It was the late 1960s, recalls Payne, and "I felt that what I was doing was not relevant to the problems that assailed the world around me. The wild world I loved above all else was being destroyed. Then I thought of whales." Commercial whaling was then in its heyday, with tens of thousands of whales slaughtered each year. "I thought, If I studied whales, maybe I could find a way to change their fate."

CREDITS: (TOP TO BOTTOM) FLIP NICKLIN; CHRIS JOHNSON/OCEAN ALLIANCE

A big question at the time was "just what whales are doing with such big brains." Payne suspected that they were using them to process and communicate complex sounds, but "I had never even seen a whale." So, he bought a ticket for Bermuda, where humpback whales were known to pass in their migrations. There he met Frank Watlington, a Bermudian engineer studying underwater sound for the U.S. Navy. The Navy was interested in listening for Soviet submarines, but in his spare time, Watlington had also recorded hours of bizarre underwater sounds that Payne later confirmed were coming from whales.

Payne spent weeks wearing a pair of headphones, listening over and over to one tape in particular. The whales were producing very complex vocalizations—traversing eight octaves in pitch from deep, organlike rumbles to high-frequency, flutelike glissandos—but there just wasn't any obvious structure. Then it suddenly came together. He noticed that the entire performance repeated after about 15 minutes. Payne was ecstatic. It isn't just random, he thought. "These are repeated, rhythmic sequences: They're songs!"

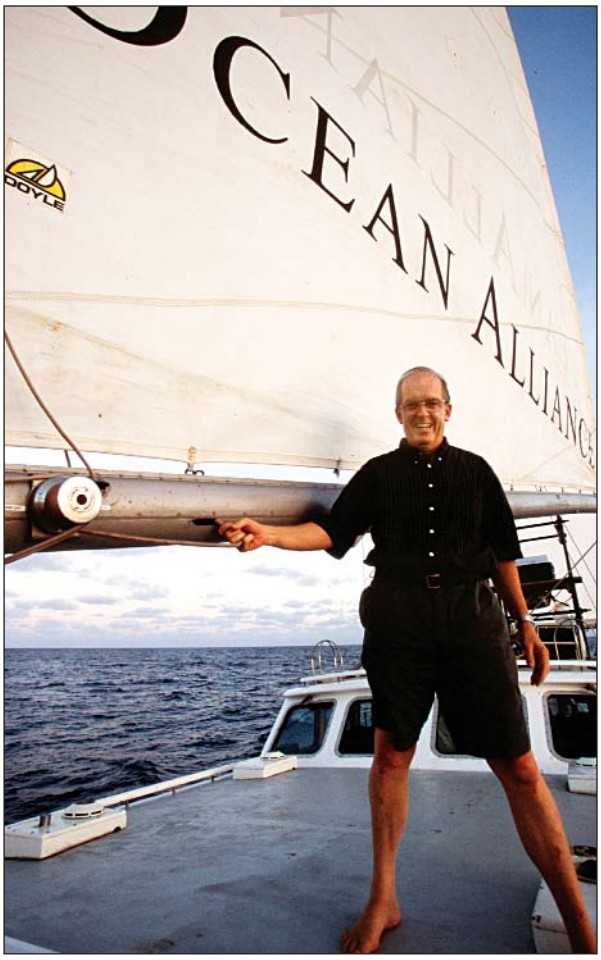
Payne and whale advocate Scott McVay, then an administrator at Princeton University in New Jersey, later demonstrated the song structure together. This was long before the days of home computers. McVay had access to a machine that transcribed sounds onto paper with a stylus. Sure enough, the repeating structure was plain to see. The "pioneering, detailed studies" were among the first to show "the significance of sound to marine mammals," says John Hildebrand, a bioacoustics researcher at the Scripps Institution of Oceanography in La Jolla, California.

Just what exactly the whales are saying to each other is another question, one that Payne and others have pursued ever since. He later proposed that the sounds made by two other very loud-voiced whales, the blue and fin whales, can carry clear across deep ocean basins. Payne's working hypothesis is that the songs of humpback whales are sung by males to attract females and threaten other males; the same may be the case with the songs of blue and fin whales. But he thinks that evolution has also endowed these whales with the ability to share information across entire oceans, perhaps to clue each other in to the whereabouts of prey in the ocean's ever-shifting feeding grounds.

Since then, says Christopher Clark, a marine biologist at Cornell, Payne has been an "inspiration" to a generation of whale researchers and has invented many standard techniques, such as identifying individual whales by photos of their natural markings.

The discovery of whale song not only propelled Payne's career but lifted whales into the public gaze: The "Save the Whales" movement was born. "Most people's idea of whales was limited to *Moby-Dick*," recalls Payne. So he teamed up with poets, musicians, and "anyone he could get hold of" to generate sympathy. The haunting songs beguiled the public: A vinyl record of Payne's humpback tapes, included in the December 1976 issue of *National Geographic*, is still the largest single print order in the history of the recording industry. Payne went on to host, write, or direct several award-winning documentaries about whales for television as well as an IMAX film.

Governments responded to the surging interest by creating the largest animal sanctuaries on Earth—the Indian Ocean north of 55° south latitude in 1979 and later most of the Antarctic Ocean, both of which remain no-whaling zones. Then in 1982, a worldwide moratorium on commercial whaling came into effect.



Ocean crusader. After a career at Rockefeller University, Roger Payne formed the Ocean Alliance to promote ocean preservation.

CREDIT: CHRIS JOHNSON/OCEAN ALLIANCE

For his championing of whales, Payne has been showered with honors, including a MacArthur Fellowship, appointment as one of the "Global 500" by the United Nations, and even a knighthood from the prince of the Netherlands. But saving the whales has also come at a price. In 1985 he left Rockefeller to devote himself to the Ocean Alliance, which he had incorporated in 1981 to promote the preservation of the ocean. The move later seemed like "one of the bigger mistakes of my life," he says. Keeping the nonprofit afloat "has left me no more than 10% of my time for basic research, which is the love that got me into all of this in the first place."

But here aboard the *Odyssey*, among the whales again, Payne is in his element. He first had the idea for the voyage 26 years ago. To make this possible, Payne and the Ocean Alliance raised $3 million from private donors and foundations, about $750,000 short of what is needed to complete the voyage. "It's taken a long time to realize this dream," he says, "but it's finally come true. It's so good to be doing research so far from land."

Canaries of the sea

"We've got a blow at 1 o'clock, about 300 meters!" crackles a voice over the radio from the observation deck. In the distance, a white plume floats over the water like a puff of steam. Moments later, a second plume, smaller than the first, jets into the air. "Make that two blows." Bob Wallace, the ship's engineer at the helm, closes in and then cuts the engines. *Odyssey* glides quietly closer to the pair.

Payne may be 69 years old, but he's the first to run out to the very front of the boat and clamber onto the bowsprit. This puts him in a precarious spot far beyond the safety of the deck, rising and dipping over the waves, but it affords the best view. At first they look like a couple of gray barrels floating in the distance, but once the *Odyssey* is less than a boat-length away, the whales' full, submerged forms take shape beneath the chalky blue surface: The adult is as big as a school bus, while the juvenile is about half that size. And these are small by sperm whale standards. A full-grown male can reach 18 meters in length and weigh over 50 tons. The only part of each whale above the water line is the tip of its massive, squared-off head, exposing the single S-shaped blow hole offset to the

left side. The two whales seem supremely calm, taking a breather before swimming down for more squid.

Just when the whales loom close enough for the crew to see the sky reflected off their glistening skin, they begin to roll into a dive. Their heads disappear as their enormous backs, covered with crenulations like giant sea prunes, breach the surface, followed by their tails in a graceful arc. Before the whales' door-sized flukes slap the water for the plunge, Rebecca Clark, a Canadian research assistant who has been aboard *Odyssey* for the whole voyage, takes aim with a crossbow from her perch on the bow. The orange-feathered arrow sails down and with a sharp "pock!" bounces off the adult's flank. This is no ordinary arrow: Its tip forms a tiny cylinder like an apple corer, gouging a plug of skin and blubber the size of a pencil eraser before springing back out.

The arrow is scooped up with a net and received with a cheerful "Thank you!" by Veritee Steptoe, an Australian research assistant leaning out of the pilothouse and wearing a white lab coat over her pink and neon-blue surfer shorts and tank top. Payne spots the next one: "Another blow at 3 o'clock!" he calls from the bowsprit, and *Odyssey*'s engine rumbles to life.

Long after the last whale is sampled and the crew has settled in for the night, Clark and Steptoe's work is just beginning. After dissecting the samples, they must parcel them into a range of solutions and file them in the freezer. All the samples will be shipped back for analysis and archiving to Celine Godard, a toxicologist at Woods Hole who directs *Odyssey*'s pollution research.

A picture of the extent of pollution is beginning to emerge from *Odyssey*'s "mountain" of raw data, says Godard. Every whale sampled and analyzed from the Pacific—even those in the most remote waters—has polychlorinated biphenyls and DDT pesticide in its blubber. The whales' meals of fish and squid are almost certainly the source of the contamination, Godard says. "It's sobering to discover that these toxicants are distributed globally," says Payne, "although how dangerous a threat they pose at low concentrations is not yet known." "People are largely unaware of POPs," adds Sylvia Earle, an oceanographer and former chief scientist of the U.S. National Oceanic and Atmospheric Administration, who says that Payne's work could be a well-timed "wake-up call."

Measuring the chemicals in whale blubber is only the first step, because although the toxicants accumulate during the lifetimes of whales, they do undergo some metabolism. We need a way, explains Godard, to measure lifetime exposure to contamination, because this is the best way to use whales as measuring sticks of global pollution. To do that, the *Odyssey* team is fine-tuning a molecular test that measures the amount of an antitoxicant protein called CYP1A1 that accumulates in response to contamination. Because this test requires fresh samples, it has to be performed immediately. So as the small hours of the morning roll by, the only light on *Odyssey* comes from the lab where Clark and Steptoe are toiling away. Samples are carefully sectioned into minuscule chunks and soaked in solution. Eventually the CYP1A1 data should add up to a tool for estimating exposure, turning whales into pollution detectors.

Grim tale from the deep. Toxicologist Celine Godard says that every sample analyzed so far from the Pacific contains pollutants.

While they're toiling away, Steptoe and Clark must attend to their share of the ship's "glamorous" duties: keeping watch to avoid collisions, preparing meals for the 12 people onboard, and cleaning the toilets. "We've been very lucky," says Steptoe, because the weather has been clear and the boat's rocking gentle. But when the seas are rough, "you need five hands" to juggle chemicals and samples. "Plus you worry about things taken for granted in labs back on land," adds Clark, such as making sure the generator is still powering the freezers and checking that none of the data sheets has blown overboard. "But as long as everyone knows what job they're supposed to do, it all works like a well-oiled machine," says Steptoe. "Well, most of the time."

Wired for whales

As the whales vanish into the dark depths, Payne turns to Chris Johnson, the *Odyssey*'s media producer, who is leaning over the railing with a video camera like a paparazzi. "Wow. Did you get that?" he asks. In the coming days, the images will be seen by thousands of people tuned in to Payne's other mission: to "share what we learn out here in real time."

Every day Johnson has kept fans abreast of the voyage—posting everything from scientific reports and videos on conservation threats to interviews with local scientists (see www.pbs.org/odyssey). "Following the whales around the equator has brought us to the most isolated island nations on the planet," says Payne, "and what we're finding is that their unique, fragile ecosystems are under constant threat from industrialized countries that want the right to fish, whale, and develop luxury resorts." Most islanders "don't realize what they have to lose by granting these rights," he says. "Since they rarely have Internet access," says Genevieve Johnson, the ship's education officer and the other half of this husband-and-wife team, "we have to take this information to them."

The Johnsons practice what they call "guerrilla education," having so far come ashore in 14 countries to date and given multimedia presentations about marine resources to more than 20,000 local people. They leave free educational packets with schools and even bring children and teachers aboard for days at a time to show them how marine science is done.

Odyssey's educational mission is leaving significant changes in its wake. After a workshop organized by Godard and presented to the environmental minister of Papua New Guinea in 2001, the government designated its entire exclusive economic zone—a 2.8 million square kilometer area—as a marine sanctuary. *Odyssey*'s next whistle stop is the Mediterranean this summer, one of the most polluted and populous bodies of water in the world. "We want to light a fire there," says Chris Johnson, "and really get people thinking about the environment that's right on their doorstep."

Odyssey cuts an arc through the water, guided by a new cluster of underwater clicks from feeding whales. Payne watches the members of his crew with obvious pride as they scramble to their stations. "All this hard work is going to pay off when the results are published," he says. "I think that whales will focus the world's attention once more, and hopefully we'll take action to reverse or at least slow down whatever environmental damage we're doing." There's still a year left in the voyage as planned, although Payne worries that there isn't enough money to cover it. He hopes the whales will help reel in research partners and donors.

"It's so ironic," Payne says, scanning the horizon for white plumes. "We've hunted whales to the point of extinction. And now, the whales are helping us to save ourselves."

–JOHN BOHANNON

John Bohannon is a writer based in Berlin.

CREDIT: CHRIS JOHNSON/OCEAN ALLIANCE