

PART 2

What happens underwater?

By Polly Shulman

How Have Scientists Studied Blue Whales in the Past?

Humans have been fascinated by whales for thousands of years. These giants of the deep swim through our myths. They appear in some of our oldest writings. But studying them is hard. Blue whales, especially, are too big to capture and keep alive to study. People used to hunt smaller whales from wooden boats, but blue whales are too big for that. Also, they dive deeper than human divers can follow. So until recently, scientists had only a few ways to learn about blue whales. They could examine the bodies of whales that washed up on shore. Later, after they designed stronger, faster boats powered by motors, they could study animals killed by hunters. They could dissect them to learn about their anatomy and even behavior. For example, they could open the whales' stomachs and look at what the whales ate. But everything the scientists knew about whales they learned on shore or at the surface of the ocean.



Figure 1. Beached whale. Until recently, everything we knew about whales we learned by studying them on shore or just beneath the surface. Photo © Danny Frank/AGE Fotostock

Watching from the surface, scientists found out that blue whales typically dive for about 10 to 20 minutes when they're feeding. When the whales are less active, they can hold their breath longer. Sometimes they dive for more than 30 minutes. When scientists talk about a whale's dive, they don't mean just the trip downward. They also mean everything else the whale does under water. That includes moving deeper into the water, performing underwater activities, and returning to the surface to breathe. But whales spend most of their time beneath the waves—sometimes far beneath. So what does a blue whale do underwater?

The Scientists

Dr. Jeremy Goldbogen, Dr. David Cade, and Shirel Kahane-Rapport are part of a group of marine biologists at Stanford University's Hopkins Marine Station in Pacific Grove, California. (Goldbogen is a principal investigator and Cade and Kahane-Rapport are researchers in his lab.) These scientists have revolutionized the study of whale behavior. They developed multi-sensor tags and attached them to whales. They began using the tags in 2014. Since then, they've attached almost 300 tags to whales belonging to six species throughout the world's oceans. Many of those whales are in Monterey Bay, near where the group works. The tags gather many kinds of data about what the whales are up to underwater.

The biologists want to understand how these marine giants evolved and live. But they also hope that their research can aid in whale conservation. To help protect whales, scientists and regulators develop fishing regulations. They map shipping routes. And they create protected areas. To do this, they need to know about the whales' behavior. That includes things like where and how the whales feed, migrate, communicate, mate, give birth, and feed their young. The more the scientists and regulators know about whales, the better they will be able to protect them.

Data collection is an extreme sport. "The first couple of times you tag a blue whale, your legs are shaking," says Goldbogen. "You're trying to just focus and make sure you get that tag in just the right spot. But it's an absolutely amazing experience."



Figure 2. Tagging a whale. Marine biologists on Goldbogen's team place a tag on a whale as it comes to the surface. Photo © AMNH

The researchers go out on small boats. They attach tags with sensors on them to long poles. They hang off the edge of the boat and when a whale surfaces to breathe, they pull up alongside. Quickly, they attach the tags via suction cup to the giants. “It’s a lot of adrenaline,” says Cade. “You’re trying to get this small device on a large whale. You have a 20-foot pole, and you have a four-second window in which to get the boat close enough to put it on the animal, and then get out of the way. It takes a lot of coordination and teamwork.”

The team uses different types of tags depending on what they want to find out. To learn about long-term behavior such as migrations, they need tags that will stay on the whale for weeks or months. For that they use “very small darts that can embed the tags in the blubber,” says Goldbogen. But those long-term tags can’t hold much data. Sometimes they want to learn about complex, short-term behaviors, such as feeding and acrobatic movements. For that they need to collect detailed data. That requires more sensors and bigger tags. The scientists don’t want to burden the whales with that much weight for months at a time. So they use tags that attach with suction cups. These tags don’t stay attached for very long. Typically they fall off within a day. And they’re completely harmless to the whale.

The suction tags have lots of different sensors. Some sensors record how fast and deep the whale is diving. Some record how it moves through

Lemon Lime Froback Whale Tag

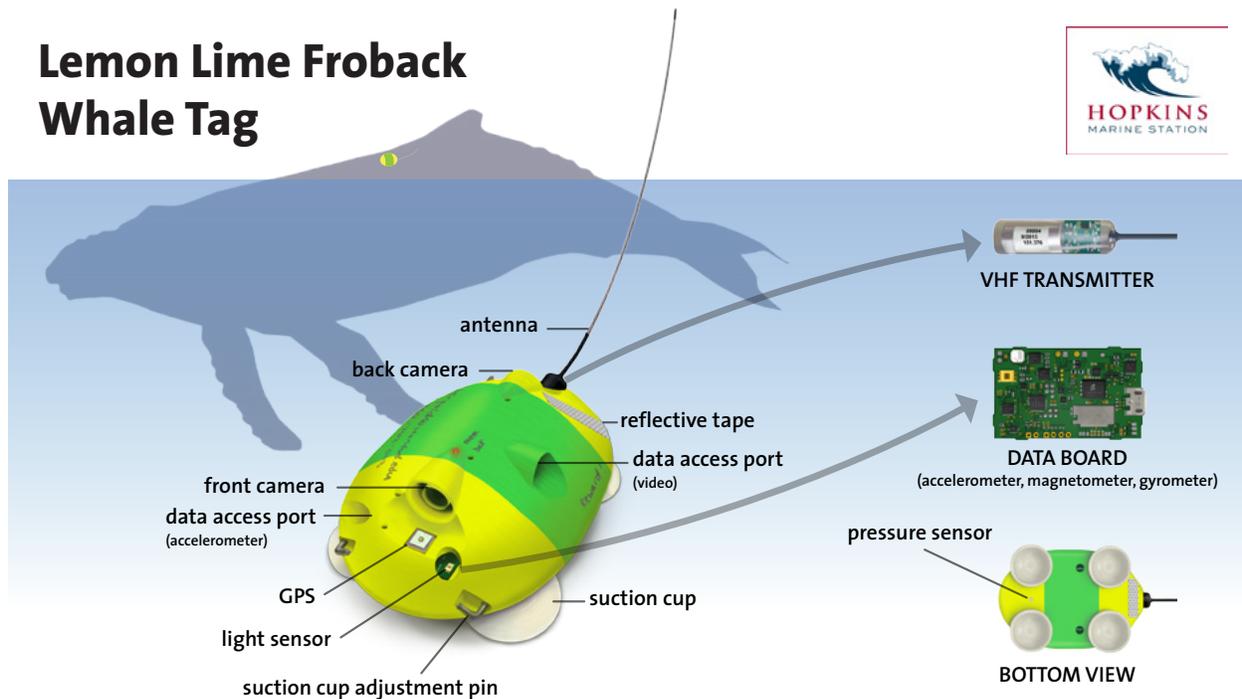


Figure 3. Whale tag with suction-cup attachment. Illustration by Alex Boersma

the water. Some even record the sound of water rushing past an animal on the move. Front- and back-facing cameras take video of the whale's surroundings. After a few hours, or sometimes a day or two, the suction fails. Even if the suction is still going strong, the patch of skin it's stuck to may not be. Whales have layers of skin that they shed naturally. When the skin falls off, so does the tag.

Once the tag falls off, it floats to the surface. There it sends out a radio signal. The researchers use the signal to track the tag. They scoop it up and upload that data to a computer for analysis. Tags can be used again and again, as long as they're not lost at sea.

The Technology

Tag sensors:

Accelerometer measures forces of acceleration. (Acceleration is the rate at which an object's velocity changes.) This sensor works with the magnetometer (see next bullet point). Together they provide information

about a whale's orientation. It's like the way a cell phone that senses whether you're holding the phone in portrait or landscape orientation. The tag's accelerometer uses gravity to detect which way the animal is facing—whether up, down, or somewhere in between.

Magnetometer measures the pull of magnetism. Like a compass, this instrument detects which way the whale is facing in the north-south/east-west direction.

Sound recorder uses hydrophones, which are underwater microphones. This instrument senses the sounds in the whale's environment. It listens for the whale's calls and the sounds of its movement through the water. It also listens for the noises of other animals, including those produced by people, and machines.

Video recorder allows researchers to see the whale's environment. It has two cameras. One faces front and the other faces back. This is especially helpful for observing the whale's interactions with other organisms, including its prey. It's also helpful for observing how the whale is moving its body parts. For example, the front-facing camera allows the scientists to see when the whale opens its mouth to take a gulp. And the back-facing camera allows them to watch its tail movements.

Light sensors, which measure the amount of light nearby. (The light sensors don't record images. They just measure brightness.)

VHF transmitter sends out very high frequency (VHF) radio waves. This alerts the researchers when the tag has floated to the surface. Then they can go retrieve it.

GPS (global positioning system) works just like the GPS on your phone to determine location. For the whale it works only in two- to three-second periods as the whale breaks the surface. This may or may not be long enough for the tag to communicate with satellites and assess its position.

Pressure sensor measures water pressure. The scientists use this to tell how deep in the ocean the whale has dived.