

Satellite Tagging Humpbacks in the South Pacific: Windows on the Whales' World

Scientists Alex Zerbini and Phil Clapham with the National Marine Mammal Laboratory's (NMML) Cetacean Assessment and Ecology Program participated in setting up a satellite tagging project for humpback whales in the Cook Islands (South Pacific) beginning in August 2006. The work was conducted in collaboration with Nan Hauser (Cook Islands Whale Research), the South Pacific Whale Research Consortium, and the Greenland Institute of Natural Resources. NMML provided three Argos-monitored satellite tags and methodological expertise; the tags were deployed by Hauser and her field team, which included Ygor Geyer from Zerbini's Brazilian research group. Their efforts led to the first documented migratory movement of any humpback whale in the South Pacific and the first connection of any kind between the Cook Islands and a high-latitude feeding ground.

Humpback whales are among the widest-ranging animals on Earth. Each year, they leave productive summer feeding grounds in high latitudes to undertake a migration that will take them anywhere from 1,500 to 5,000 miles, into the warm tropical waters where they mate and give birth to their young. During this time, they do not eat for weeks or months, subsisting instead on the thick layers of blubber, which have been steadily built up over the summer feeding season. While on their breeding grounds, the males sing their long, haunting songs and compete (sometimes quite aggressively) over mating access to females. Pregnant females give birth to their calves in the warm tropical water and diligently nurse them with a fat-rich milk that promotes rapid growth. Then, at winter's end, all the whales make the long journey back to polar waters, and the annual cycle begins once more. It is a cycle that has been repeated for thousands of generations of whales.

In the Southern Hemisphere, humpback whales feed in the frigid waters off Antarctica, and they breed and calve in coastal or island waters that stretch in a global band between the Equator and the Tropic of Capricorn. A particular whale's feeding and breeding grounds are deter-

mined largely by where that whale's mother comes from. For example, if a female feeds in the waters south of Australia and migrates to Fiji to give birth, then her calf will probably use the same feeding and breeding areas.

Except that Fiji no longer hosts many whales. Today, only a few humpbacks return to Fiji, and one can wait a long time between sightings, even during the supposed peak of the season in August. Yet it was not always so. In the 1950s, the late Dr. William Dawbin conducted annual surveys for humpback whales at various places in Fiji and recorded several hundred whales a week at the peak. However, this was before 1959, when the U.S.S.R.—which at that point had already been engaged in a secret campaign of illegal whaling for more than 10 years—began a slaughter of humpback whales that was excessive even by the unrestrained standards of 20th century whaling. Over the course of just two winters, Soviet factory ships slaughtered almost 25,000 humpbacks; most met their end in the portion of the Antarctic that lies south of Australia and New Zealand. The result was an instant crash of the population—so rapid that coastal whaling stations operating to the north in New Zealand and eastern Australia almost immediately went out of business for lack of whales. We do not know how small the surviving humpback whale population was, but it was likely just a few hundred animals.

In the four decades since those dark days, humpback whales have recovered remarkably well, in some areas. Off eastern Australia, for example, the population is now on the order of several thousand animals and continues to grow at a healthy rate. But in other places, including Fiji, New Zealand, and New



In 2007 scientists working in the South Pacific conducted a collaborative satellite tagging project in New Caledonia and the Cook Islands. By attaching a transmitter to a whale, its movements can be remotely followed on a daily basis by satellite. Photograph © 2007 Paul Hilton/Greenpeace International.



Scientists with Cook Islands Whale Research and Operation Cétacés, working with Brazilian scientist Ygor Geyer, succeeded in deploying 20 satellite tags on humpback whales in August and September 2007. Photographs © 2007 Paul Hilton/Greenpeace International.

Caledonia, there is little or no sign of such recovery. Whether this is because the cultural memory of the existence of these formerly populous habitats died with the slaughtered whales is not clear.

And today, after almost half a century of protection, it is possible that humpback whales will once again be hunted in the Antarctic. Although Japan has suspended its plan to catch humpback whales this season, it still intends to kill 50 humpbacks a year in the future, together with the 935 minke whales and 50 fin whales that are currently taken in this region. Under the terms of the 1946 International Convention for the Regulation of Whaling (which established the IWC), any nation may issue its nationals a permit to kill whales for the purpose of studying them. The provision (known as Article VIII) made perfect sense 60 years ago when the Convention was signed; in those days, there was no other way to study whales except by killing them.

The provision never included a limit to the number of whales that can be killed, because in 1946 no one imagined that Article VIII would ever be used as a way of getting around a ban on whaling. In this light, it is instructive to look at the numbers: the annual scientific whaling catch by Japan is now roughly equal to half the *total* catch by all whaling nations combined over the past half century.

One of the big problems with Japan's intended catch of humpback whales is that it is impossible for a harpooner to tell whether the whale in his sights comes from the relatively healthy population off Australia or from one of the small, unrecovered stocks in places like Fiji and New Caledonia. Although 50 whales a year may not seem like a huge number when set against the massive totals racked up by the U.S.S.R. and other whaling nations in the 1950s and '60s, such catches have the potential to threaten the remnant populations that are struggling to make a comeback.

Key to all of this is knowledge of population structure. Specifically, in order to properly manage any whale species, one needs to know how many populations exist and their size and

relationship to one another. The importance of this can be illustrated with a simple example. Imagine that there are 1,000 humpback whales in a single population, that these animals mix freely with each other, and that they all breed together. Now imagine that each year a certain number of these whales are killed by "unnatural" causes—whaling, entanglement in fishing gear, or ship strikes. The impact of these mortalities on a single stock of 1,000 whales will be far less than if the 1,000 animals actually make up *two* separate populations, with one being 900 and the other only 100 animals. The impact of any number of deaths on a population of 100 will obviously be much greater than if that same number of mortalities is taken from a single, mixed stock of 1,000 animals. In other words, you need to know how many populations you're dealing with before you can make sensible decisions about how to manage them.

For the purpose of management, scientists and the IWC usually define populations by drawing lines on a map. This is inevitable and convenient; but, of course, the whales themselves don't recognize such neat boundaries. Currently, the IWC recognizes seven Southern Hemisphere populations of humpback whales. Each of these populations feeds in a particular portion of the Antarctic, and these feeding areas are linked to specific breeding grounds in tropical waters. For example, humpbacks that feed in what is known as "Area V"—broadly, the area of the Southern Ocean south of Australia and New Zealand—are thought to breed off the eastern coast of Australia and in western Oceania. Management of these animals, an activity which could cover everything from conservation measures to setting future catch quotas, is all based on the assumption that this population is largely separate from others (which in turn are managed according to our knowledge of their particular size and structure).

How do we study population structure? There are various methods, most of which involve somehow tracking whales from one place to another and, in the process, testing whether our notions of the structure and boundaries of their populations are accurate. For example, if a whale from eastern Australia suddenly showed up in the Antarctic south of Africa, this would challenge the current idea that the Australian population is linked to feeding grounds in the polar waters south of that continent. How serious a challenge this would represent would depend upon whether such movements turned out to be fairly common or looked instead like a one-shot case of an "aberrant" wandering whale. To date, incidentally, no such movement has been detected, although scientists working in the Indian Ocean did recently record a whale going from the east coast of Africa to the west!

The principal means of tracking whales from place to place are three-fold. The first is photo-identification, which involves photographing the unique markings on the underside of a humpback whale's tail. These markings are like a fingerprint in that no two whales have exactly the same tail pattern. This feature has been used to identify many thousands of individual humpback whales all over the world.

Photo-ID has allowed scientists to follow individual whales over periods of literally decades in some areas, and also to document the reproductive success of females and their offspring over several generations.

A second method is similar but more high-tech. By taking a tiny sample of skin from a humpback whale through a biopsy—in which a dart, fired at a whale from a crossbow, harmlessly takes a small skin sample before bouncing off into the water—scientists can examine the whale's DNA and conduct many sophisticated and highly informative analyses. These include determining the animal's sex (which usually cannot be done visually), as well as assessing its maternal lineage, and constructing a genetic profile that allows the whale to be individually identified. As with photo-ID, where two photographs of the same whale in different areas can be matched, a humpback that is biopsy-sampled in two different places can be unequivocally identified as the same individual through genotyping. All of these tests and many more can be conducted with a single tiny piece of skin, which is rather different from the "whole-animal" sampling employed by Japanese whalers.

With either of these methods, an individual whale can be resighted or resampled again and again, giving us ever-more information about its movements over the course of years or even its entire life (something which, needless to say, is not possible when a whale is killed). Using these methods, thousands of whales have been documented traveling over sometimes huge distances. For example, in the North Atlantic, some humpback whales have been followed for more than 30 years and observed



Satellite tagging, in combination with other nonlethal approaches, such as photo-identification, genetic analysis, and other techniques, can provide invaluable information for the conservation and management of humpback whales. Photograph © 2007 Paul Hilton/Greenpeace International.

at migratory endpoints as far apart as Norway and the Caribbean.

What photo-ID and genetics cannot do is tell us the daily movements of animals or track their wanderings through the large areas of ocean in which human observers aren't present. We may photograph a whale in the Cook Islands or New Caledonia and then see it again off Tonga (in fact, many such matches have been made with both photographs and genetics); however, we don't know the many details of where it goes in between these brief snapshots of its life.

This is where the third technique comes in. By attaching a transmitter to a whale, its movements can be remotely followed on a daily basis by a satellite. The transmitter sends a signal to an Argos satellite, which in turn transmits the data to a ground station—and a scientist with a laptop can access this information from anywhere in the world. Photo-ID and genetic sampling require scientists to be next to the animal, and it is impossible to follow a whale in rough weather, or at night, or far from the safety of coastal waters. In contrast, a tagged whale can be followed anywhere on Earth at any time. Not only are scientists able to see the end points, they learn every detail of the whale's movements without ever having to relocate the animal in the vastness of its huge migratory range. (Traditional methods require you to find the whale to photograph or biopsy it, which is as much a matter of luck as anything else).

This year in the study initiated by NMML in 2006, scientists working in the South Pacific were funded by Greenpeace International to conduct a collaborative satellite tagging project in two locations: New Caledonia and the Cook Islands. New Caledonia was chosen because this is one of the small, unrecovered populations about which we have considerable concern relative to the imminent Japanese whaling effort. Dr. Claire Garrigue of Operation Cétacés, who directs the study of humpback whales in New Caledonia, estimates that the population is in the low hundreds, with little sign of recovery from whaling. Given its location, we had strong suspicions that the New Caledonia humpbacks migrate into the Area V feeding grounds, which will be one focus of Japan's scientific whaling in the coming years; and, indeed, a recent genetic match of a whale moving between these two areas has confirmed this.

Whales from the Cook Islands likely migrate farther to the east than the New Caledonia

animals, and the population there is even smaller. Nan Hauser, who directs Cook Islands Whale Research, typically photo-identifies only 60-70 whales a season.

Again, tagging fills in the gaps. Claire Garrigue may photograph a whale in the large lagoon off southern New Caledonia, and a few weeks or years later Nan Hauser may see that same whale a mile off the coast of Rarotonga. These matches are very important scientifically; but the whale's movements in between these two far-flung points in time and space are largely a mystery. Do New Caledonia whales travel to New Zealand? Do whales in the Cook Islands travel east or west when they leave, or are their movements all over the map? Satellite tagging can address exactly these kinds of questions and, in doing so, can provide critical information about population structure and behavior for use in management.

In September 2006, Hauser's project placed a NMML satellite tag on a whale, a mother observed off the main island of Rarotonga, and watched over 4 months as the animal migrated from the Cook Islands into the Southern Ocean. By the time the tag ceased transmitting in late January 2007, the whale had traveled almost 4,000 km to the Antarctic Circle and was close to the boundary between two IWC management areas, which came as a surprise to many.

In August and September 2007, Garrigue and Hauser, working with Brazilian scientist Ygor Geyer, succeeded in deploying 20 satellite tags on humpbacks: 12 in New Caledonia and 8 in the Cooks. All scientists working on humpbacks in the South Pacific eagerly awaited the streams of data that came from the tags, and they were not disappointed. Although all the tags ceased transmission before any of the whales reached the Antarctic, the information they yielded was spectacular.

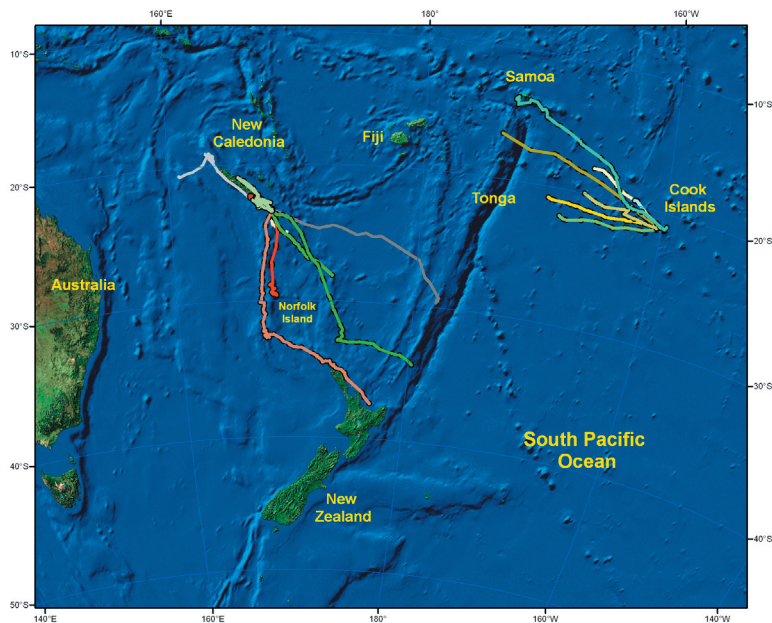
Because by necessity we usually work close to our own coasts, we tend to fall into the trap of seeing humpback whales as coastal animals, yet they are not. In New Caledonia, several of the 12 tagged whales traveled offshore from the lagoon on the southern coast to a remote reef system to the southeast, where some remained for an extended period. Until then, no one had any idea of the apparent importance of this offshore habitat to the animals. Garrigue is planning photo-ID and genetic sampling in the area next year, and the tagging results may well set in motion future efforts to protect this previously unknown habitat.

One whale surprised everyone by leaving the southern lagoon, moving up the entire length of the western coast of New Caledonia, and then traveling hundreds of miles west to the area of reefs and islands known as the Chesterfields. This provided an interesting historical insight, because in Herman Melville’s day the Chesterfields had been one site of American “Yankee” whaling in the 19th century.

And then there were the long-distance migrants. Some of the whales tagged off New Caledonia moved to Norfolk Island and/or to the northern coast of New Zealand, thus filling a key gap in our knowledge of their population structure. We had always wondered where New Zealand whales went (there were a few photo-ID matches prior to this project). The movements between these two areas are important, because whales in neither area have shown signs of recovery from whaling; thus, the link is a logical one that has significant implications for conservation. In this regard, the fact that none of the whales tagged in New Caledonia moved to Australia provides further support for the idea that the former is a largely separate stock whose recovery is not being accelerated by any influx of animals from the much larger Australian population.

In the Cook Islands, the behavior of the eight tagged whales was characterized by one huge surprise: rather than spreading out and traveling in different directions, they *all* moved west or northwest. One animal traveled all the way to American Samoa, while others moved through the many islands and reef systems that make up the Tonga group. Does this indicate that whales enter the Cooks in a kind of “wave” that sweeps through the islands from the east? We don’t yet know, although such movements have been observed among humpbacks tracked by photo-ID in another breeding area, the West Indies.

Another surprise was that even though some tags continued transmitting well into October, which is quite late in the season, none of the Cook Islands whales showed any signs of turning south towards the Antarctic. This is in contrast to some of the New Caledonia whales, who began moving south shortly after being tagged. The variability in these move-



Tracks of humpback whales tagged in the Cook Islands and in New Caledonia and monitored by Argos satellite.

ments, and the consistency with which the Cook Islands animals all traveled west, have important implications for a variety of issues ranging from population structure to how these animals navigate. Currently, NMML scientists and their collaborators are looking in more detail at the tracks of these animals, assessing whether their movements can be linked to discernable features in the ocean, to the seafloor, celestial cues, or perhaps even the Earth’s magnetic field—all of which are possible mechanisms used by humpback whales to find their way across the vastness of the ocean.

As a founding member of the South Pacific Whale Research Consortium which coordinates cetacean research and conservation across Oceania, NMML scientist Phil Clapham has a long history of involvement with work in this region. Clapham is working to find support for more satellite tagging in this region in 2008. With just these 20 animals, we have already learned more about movements and connections of whales in the South Pacific than was known before. Satellite tagging, of course, cannot tell us everything; rather, it is used to address some specific areas of research. But in combination with other nonlethal approaches, such as photo-identification, genetic analysis, and other techniques, it can provide invaluable information for the conservation and management of these animals.

By Phil Clapham and Alex Zerbini