The Sciences

Why Do Whales Sing?

BY PETER TYACK

Reprinted from *The Sciences,* September 1981
Copyright © 1981 by The New York Academy of Sciences

Why Do Whales Sing?

To keep in touch is only half the answer

BY PETER TYACK

WHEN Jacques Cousteau described the sea as "the silent world," he was thinking of our own experience —the underwater world of scuba divers. For humans, it is difficult to hear and nearly impossible to speak when underwater; deprived of conversation, the divers' experience is primarily visual. But the sea is actually far from silent. Sound travels much more effectively through water than through air, while light penetrates seawater poorly. It is understandable, then, that many animals adapted to life undersea rely heavily on acoustic communication. Indeed, snapping shrimp and the fish known as grunts take their names from the loud sounds they produce, and dolphins locate objects beyond their visual range by listening to their voices' own echoes.

We have known about the sounds of the "silent world" since World War II, when the vocalizations of marine animals were picked up by Navy sonar operators listening for ships. Cetaceans (the order of mammals that consists of whales, dolphins, and porpoises) seem to be more vocal than most, as is obvious to anyone who has listened to the constant high-pitched chatter of a group of dolphins or to the elaborate songs of humpback whales. But only recently have we begun to understand how cetaceans use their vocalizations.

Peter Tyack is a graduate student in animal behavior at Rockefeller University. He works with Roger Payne, of the New York Zoological Society, and Donald Griffin, of Rockefeller.

The sounds of captive dolphins were the first to be studied, at a time when most knowledge about the large whales came from dead specimens harpooned by whalers or stranded on beaches. However, during the last decade, there has been a dramatic increase in field studies of large-toothed whales, particularly sperm and killer whales, and of wild baleen whales, such as humpbacks and right whales. This work sheds new light on the roles that vocal communication plays in the lives of these animals.

Through the work of John Lilly and others, the topic of dolphin communication is well known to the public. Lilly's writings have prompted many films and imaginative books, creating the impression that dolphin communication is a well-studied phenomenon and that dolphins have a sophisticated language that humans have at least

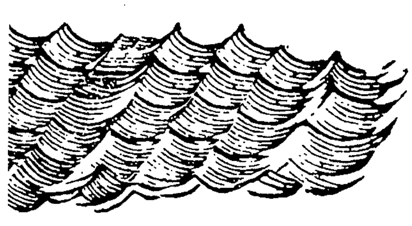
partly decoded. But, in truth, there have been very few investigations of how dolphins use their sounds, and those few that have been published tell a confusing, often contradictory story.

Most species of dolphins are very social; in nature, dolphins are seldom seen alone and rely upon their social groups for foraging, for protection from predators (such as killer whales and sharks), and for support in case of injury. (A wounded dolphin may be physically supported in the water by other dolphins for many days.) When a dolphin vocalizes, it is usually within sight and earshot of other animals in its group.

Evidence from studies of both captive and wild dolphins indicates that many of the sounds they make tend to occur in specific situations. For example, Lilly has described a type of whistle that captive bottlenosed dolphins (*Tursiops truncatus*) make when in physical distress. Trainers have learned to heed this signal—when they hear it, they dash over to see what is wrong. Other *Tursiops* sounds are usually made in conjunction with visual displays. There is a certain pulsive noise, for instance, that dolphins often make while snapping their jaws threateningly; other dolphins move rapidly away from an animal performing such a threat. In wild dolphins, too, the pattern of vocalization varies with the context. In a study of wild bottlenosed dolphins in Argentina, I found differences in both the rate of vocalization and in the kinds of sound that dolphins tend to use when resting, feeding, or socializing.

LARGE whales also produce sounds while in groups. Research has focused thus far, however, on the sounds whales make when alone, an easier phenomenon to study because in a large group it is hard to know which individual is making sounds. Recent studies suggest that some of these sounds may be contact calls, signals that allow individuals to find each other even if they are far apart.

Christopher Clark, a postdoctoral student at Rockefeller, has found that some sounds made by southern right whales (*Eubalaena australis*) appear to attract other whales. He was able to test the reactions of right whales to these sounds by recording their calls and playing them back in the presence of other right whales in the area. The results were dramatic: While right whales moved away from other recorded sounds, they swam rapidly toward the loudspeaker when it played *Eubalaena* sounds, making more noise themselves as they approached. It therefore seems likely that these whales use calls to locate other whales.



Finback whales (*Balaenoptera physalus*) produce signals that Roger Payne, of the New York Zoological Society, and Douglas Webb, of the Woods Hole Oceanographic Institution, believe may also function as contact calls. The calls might help finbacks meet each other, or help a group that has dispersed over a large area to keep in touch. The remarkable thing about these signals is that they appear to be specifically adapted to carry over great distances. The sounds are extremely loud and very low in pitch; even in an ocean full of background noise from ships' propellers, they should be audible at least eighty kilometers away. Under special conditions, such as under ice or along the sofar channel that occurs in deep oceanic waters, the sound may be detectable at ranges of up to one thousand kilometers. In oceans with no propeller noises, as was the case until the nineteenth century, these sounds might be heard up to six thousand kilometers, a good distance across any ocean. Finbacks, unlike right or humpback whales, do not congregate during the winter breeding season, and it may well be that their ability to communicate over great distances has freed them from the need to gather in dense crowds during this period.

In some species of cetaceans, different groups of whales seem to have developed distinctively different calls—something akin to dialects. John Ford, a graduate student at the University of British Columbia, in Vancouver, who has studied the sounds of killer whales (*Orcinus orca*), has found that each stable family group has its own limited repertoire of stereotyped pulsed calls. Each animal within the group appears to produce the whole repertoire, and those groups most often found together sing songs that are the most similar.

Sperm whales (*Physeter catodon*) produce stereotyped series of clicks. For hours at a time, a sperm whale will repeat a unique rhythmic pattern called a coda. Listening to these clicks from sets of hydrophones placed at different locations and comparing their arrival times, William Watkins and William Schevill, both of the Woods Hole Oceanographic Institution, were able to compute the whales' locations. They discovered that sperm whales tend to disperse while underwater, separating by more than one hundred meters, well out of each other's sight. Yet when they surface to breathe every ten to thirty minutes, they come up at the same time and within tens of meters of each other. In order to regroup this way at each surfacing, they apparently maintain contact underwater with their calls.

It seems then that many species of cetaceans use sounds to stay in touch with members of their own group. But these are fairly simple tasks, and some of the signals produced by whales are much more complex than such simple purposes seem to warrant. The most complex signal produced by whales—and probably the most complex produced by any animal—is the song of the humpback.

HUMPBACKS, like other baleen whales, have an unusual yearly cycle. They spend their summers in polar waters, feeding intensively on dense concentrations of small crustaceans and fish, and then migrate to the tropics for the winter and spring, when they seldom feed, if at all.

During these seasons, the humpbacks mate, give birth, and sing. Most singing humpbacks are alone, repeating their song over and over, sometimes for hours on end. The songs sung by humpbacks within one area are similar at any one time but, although several different humpbacks often sing within earshot of each other, they never sing in unison.

The song itself is a very complicated series of musical sounds that can last for more than twenty minutes before the entire series is repeated. But the performance is perhaps a bit less impressive as a feat of memorization than it first seems. The song is composed of phrases, each of which is a sequence of sounds lasting about fifteen seconds. The sounds themselves are of such a remarkable variety that, when one hears them for the first time, it is hard to believe they are not produced by several different animals. After each phrase is sung once, it is repeated several times; then a second phrase is sung, and repeated; then a third, and a fourth, and so on. Each sequence of repeated phrases is a theme. The average song contains between five and eight themes, and each time the song is sung these themes are repeated in the same order. So the whales need not memorize a full twenty-minute song as such; they only need remember a limited number of notes, the way to structure these notes into phrases, and the order in which one theme follows another.

The songs may be less complex than their long duration seems to imply, but their most impressive characteristic is that they change slowly in almost every aspect throughout each singing season. Sometimes their length will double. Entire themes die out and new ones appear. The duration of each phrase as well as the number and sequence of sounds that compose it often vary. Even the individual sounds or notes in the phrase may gradually change in pitch, duration, timbre, and contour. All these changes are progressive and, once established, usually continue for some time.

The changes are also cumulative. Studying a sample of humpback songs recorded off Bermuda over the course of twenty years, Katy and Roger Payne have found that entire songs were transformed; not one sound from the songs' first versions was left intact in the last. Once a phrase disappeared, it never returned. Surprisingly, songs from the same population of humpbacks recorded over

those two decades appear to be as different as those sung by whales from the North Atlantic and North Pacific (whose humpback populations are separated by a continent, and therefore cannot hear each other's songs.)

Even though humpbacks stop singing for almost half the year, much less change occurs in their songs between singing seasons than during any one season. In other words, humpbacks seem to stop changing their songs when they stop singing and, with few exceptions, are able at the start of the next singing season to pick up where they left off.

Such a complex and novel phenomenon is difficult to understand. On several counts, these songs seem unlike any other cetacean vocalizations. Less than two percent of singing humpbacks sing in groups; so while singing might affect interactions between animals or roughly coordinate a large group, the songs themselves do not seem to affect behavioral interactions on as fine a level as dolphin vocalizations appear to. The complex, changing songs lack those acoustical properties necessary for long-distance transmission, so they do not seem specifically adapted for long-range communication like the vocalizations of finbacks. Finally, humpback songs are much more complex than the simple contact calls of right whales and, if the humpback songs are used similarly, one wonders why they need be so complex.

In many non-cetacean species, lone animals often repeat long, complex vocalizations during the breeding season. Most of us are familiar with the chirps of birds and the croaking of frogs, but many other creatures, from the fruit fly to the gibbon, also sing. Generally, males are more likely to sing than females, their songs communicating such varied information as species, sex, age, location, individual identity, and readiness both to mate and to engage in aggressive behavior with other males. Since males often avoid other singers, song also often acts as a spacing mechanism. Females ready to breed often ap-

Illustrations: *The wall tiles shown on these pages were made in Holland in the seventeenth and eighteenth centuries. They are from a group of twenty-eight tiles in the Barbara Johnson Collection.*

proach singers, and may even use song as a criterion in selecting their mates. To what extent do humpbacks fit this common pattern?

Clearly, to decide this question one must be able to tell males from females in the wild. But field studies of humpbacks have been complicated by difficulties in determining a whale's sex from a distance, since external differences between males and females are not obvious. Recently, Deborah Glockner-Ferrari, an independent investigator working in Hawaii, has shown that subtle sexual differences exist between males and females—differences in profile that are apparent in a good underwater photograph. And Howard Winn, of the University of Rhode Island, has shown that it is possible to identify the sex of a humpback by microscopic examination of the sex chromosomes in the cells of a small tissue sample. Using these techniques, it has been demonstrated that most singing humpbacks are male, which fits the general pattern.

Another difficulty in analyzing humpback singing behavior has to do with following a whale for a long time from a small boat. To hear whether the whale is singing, one must turn off the motor; what with the drifting of the boat and the movement of the singer (the whale may not surface for twenty minutes at a time), it is very easy to lose track of a whale. In 1979, our research team in Maui developed a strategy that solved this problem. Observers in boats listened to singing humpbacks and identified individual whales, while lookouts on a nearby hill followed the overall movement patterns of whales and boats. Communicating by radio, our team was able to track whales over considerable distances and to observe interactions among different groups.

Before our study, only scattered evidence suggested that whales did not just swim slowly along, singing for hours on end. We were surprised, therefore, when on the first day of trying our new technique, the singer we were following stopped vocalizing and joined with another whale. This proved to be a frequent occurrence. On the few occasions when singers joined with whales we knew to be female, and on other occasions when they joined with whales of unknown sex, we observed behavior associated with sexual activity in other species of baleen whales. (In spite of the great effort devoted to watching humpbacks, observation of copulation has not been reported for this species.)

Females with calves are frequently accompanied by a third whale called an escort. Earlier researchers believed this third whale to be an "auntie" that helps care for the calf. However, all of the escorts whose sex has been determined by Glockner-Ferrari have been males, and whenever more than one adult is seen escorting a cow and calf, we have observed chases and challenges but very little care-giving behavior. Escorts, in other words, behave more as if they are competing for the female than caring for the calf.

The important role singing plays in humpback courtship may help us to understand the remarkable complexity of their songs. We can eliminate several possible reasons the songs might have evolved such elaborate structure and pattern. It is not likely that their complexity relates to a reproductive isolating mechanism (which inhibits mating between members of two different species) since humpbacks are the only cetaceans known to sing. Nor is it probable that the variability of humpback song reflects variation in the vocal messages that whales communicate to one another. Since each sound is gradually modified into a completely different form, or disappears from the song entirely, it is unlikely that each individual sound represents an independent signal.

The songs, however, like countless other courtship displays in other species, may be driven toward complexity by a process of sexual selection. The theory of sexual selection has been invoked to account for such elaborate displays as the tail of the peacock and the brilliant plumage of the cock of the rock. If females of these species, through many generations, chose to mate with those males that perform the most elaborate displays, a powerful process of selection would begin.

Once the female preference for a particular display—say, the length and intricacy of a male peacock's tail feathers—was established, then development of the preference in females and development of the display in males would be mutually reinforcing. The stronger the preference of females, the stronger would be the selection pressure for further development of the trait in males. And the female benefits, too: Her reproductive success, after all, depends in part on the success of her sons. If, by mating with the male that had the most elaborate tail feathers, a female increased the chance that her sons would have elaborate tail feathers, then her sons, in turn, might be favored by females in the next generation.

If female humpbacks in the past chose to mate with those males that sang the most complex songs, then sexual selection could have driven the songs to become even more complex—even to the point of the continuous change we now observe. Strangely enough, it may be the musical quality we sense in the males' remarkable songs that reflects the tastes of female humpbacks. □