Using statistics to calculate whether whales are acting weirdly

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The researchers put measuring instruments on whales to better understand the animals and the way we humans affect them. Credit: Carsten Egevang, Greenland Institute of Natural Resources

We humans can be a scary acquaintance for whales in the wild. This

includes marine biologists tagging them with measuring devices to understand them better. These experiences can make whales behave erratically for a while. Such behavior can affect research quality and highlights an animal ethics dilemma. Now, University of Copenhagen researchers have figured out how to solve the problems with math. The work is published in the journal *Ecology and Evolution*.

Maybe you have tried taking a howling pooch or cranky cat to the vet. Regardless of your noblest intentions, your pet's experience may have been equally unpleasant. Animals react to the unknown in their own way. The case is no different for cetaceans like narwhal and bowhead whales when they encounter human generated noises such as ship noise or mining blasts in the North Atlantic—or when they are caught by well-meaning marine biologists who just want to get to know them better.

When biologists "tag" whales with measuring devices, the animals react by behaving unusually—abnormally. For example, for a while after being tagged, they may perform many atypical shallow dives and quick jerks. Such behavior is misleading when the goal is to study the animal's normal and natural behavior.

The problem is getting help from an unusual corner.

"Biologists seek to understand animals as natural beings, but their reactions turn into unnatural behavior that creates noise in the dataset. Because of this, a lot of data from just after whales are tagged ends up getting discarded. In this study, we have proposed a mathematical approach using statistical methods that can determine exactly how much data to keep," says Ph.D. student Lars Reiter from the Department of Mathematics.

Valuable for humans and animals alike

With two statistical calculations, the researcher has found a way to estimate when whales like narwhals and bowhead whales will return to their natural behavior after being tagged. It is a method that can also be used to study how animals respond to other types of disturbances.

"This research is extremely valuable to us as marine biologists who are interested in the behavior and well-being of whales. It provides us with a standardized approach by which to distinguish between natural behavior and affected behavior in whales. Thus far, we've made individual estimates that are more or less spot on," says marine biologist Outi Tervo from the Greenland Institute of Natural Resources, who collaborated with the mathematicians on the study.

The statistical method allows researchers to avoid discarding too much or too little data. If too much data is kept, it can interfere with the research results, and if too much is lost, it comes at cost to both the animals and humans.

"It really matters in terms of research, but also financially. And not least, it means something for animal welfare. If we throw away data unnecessarily, more whales will eventually have to go through the experience for us to conduct this research, which is ultimately meant to benefit the animals," says Outi Tervo.

Idea came from a parliamentary election

Whale behavior does not go from abnormal to normal with a flick of its tail. Their behavior normalizes gradually, typically over a day—and in a few cases over a longer period of time. During this transition, a whale's behavior manifests itself on both sides of an area designated as normal whale behavior. So how do scientists figure out where to make the cut?

"The idea came to me while I was standing in the voting booth during

parliamentary elections. Borrowing from the logic of the electoral system, you can consider it as if the whales—or these data points which show the whale's behavior—vote on whether they are in or out of their normal range," explains Lars Reiter.

By recording 1 positive "vote" when the behavior is within the normal range, and 1 negative "vote" when outside, the scientists can add up all the votes and find the moment at which the number of votes goes from predominantly negative to positive.

The researchers use two approaches to determine normal whale behavior. In part, they look at the whale's diving pattern, as well as its acceleration and fine motor skills.

How to calculate the behavior of animals statistically

Sometimes it hunts in the deep, while at others times, it cruises quietly at the surface. The activity that a whale is engaged in is crucial for understanding its normal energy level. Lars Reiter's method takes this into account as something new.

"Where previous research focused on the mean behavior, we instead situate a whale in an activity based on its movements—where it is assessed based on a normal value for acceleration that matches the specific activity being engaged in. We do this by using what are known as quantiles, instead of averages, because they allow us to focus on behavioral extremes. For example, hunting and resting are opposing extremes in terms of energy levels," explains Lars Reiter.

When the focus is on the whale's diving profile, on the other hand, you look at the pattern formed by the whale's overall activities. By combining depth and time, one can assess whether the distribution of different dive types is natural.

Wiser about the animals' hardships and better at avoiding them

According to the marine biologist, the data-based approach represented by the statistical method also means that researchers can now develop better, more gentle ways of tagging.

"Based on this study, we already know that the amount of time we spend putting the equipment on is an important factor for how much the animals are affected afterwards. Therefore, we can set up some time limits—where we stop and set the whale free if it takes more than X number of minutes allowed," says Outi Tervo.

A shift away from individual estimates to a mathematical standard could also mean better assessments from the veterinary oversight that tag-using research projects are required to go through.

"The method will make it so that ethical approval from a veterinary inspection is more data-based and precise. So, there is no doubt that this research is a step forward for animal welfare," says the marine biologist.

Statistical method with two mathematical calculations and one intersection

The statistical method can generally be understood as calculations with two types of tagging data—acceleration and depth, and a way of adding it up that finds the optimal intersection.

Acceleration tells about the energy level and whale movements ("jerks"). The indicators for natural behavior are divided according to whale activity, so that, for example, a high energy level is recorded as natural in connection with hunting, but not in connection with rest.

The whale's diving profile is measured in depth and time spent on a dive. Temporal impacts over a 40-hour period show a pattern of different types of dives—e.g., U-dives, where the whale stay at depth for some time, or V-dives, where the whale resurfaces quickly. The pattern is compared with normal values measured after the 40 hours.

The cut-off point for when the whale is back in normal behavior is found by counting the individual measurements as "voting for or against" normal behavior. As such, the researchers find the optimal place to divide the research data into natural and influenced behavior.

More information: Lars Reiter Nielsen et al, Using quantile regression and relative entropy to assess the period of anomalous behavior of marine mammals following tagging, *Ecology and Evolution* (2023). DOI: 10.1002/ece3.9967

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