Can data save dolphins? How scientists are using NASA data to study link between solar storms and animal beachings

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Illustration of an Atlantic White-sided Dolphin and a Long-finned Pilot Whale, two marine mammal species that strand in Cape Cod. Credit: NASA GSFC/CIL/Brian Monroe

The age-old mystery of why otherwise healthy dolphins, whales and porpoises get stranded along coasts worldwide deepens: After a

collaboration between NASA scientists and marine biologists, new research suggests space weather is not the primary cause of animal beachings—but the research continues. The collaboration is now seeking others to join their search for the factors that send ocean mammals off course, in the hopes of perhaps one day predicting strandings before they happen.

Scientists have long sought the answer to why these animals beach, and one recent collaboration hoped to find a clear-cut solution: Researchers from a cross-section of fields pooled massive data sets to see if disturbances to the magnetic field around Earth could be what confuses these sea creatures, known as cetaceans. Cetaceans are thought to use Earth's magnetic field to navigate. Since intense solar storms can disturb the magnetic field, the scientists wanted to determine whether they could, by extension, actually interfere with animals' internal compasses and lead them astray.

During their first investigation, the scientists—from NASA's Goddard Space Flight Center in Greenbelt, Maryland; the International Fund for Animal Welfare, or IFAW; and the Bureau of Ocean Energy Management, or BOEM—were not able to hammer down a causal connection.

"We've learned so far there is no smoking gun indicating space weather is the primary driver," said Goddard space weather scientist Antti Pulkkinen. "But there is a sense that geomagnetic conditions may be part of a cocktail of contributing factors."

Now, the team is opening their study up much wider: They're asking other scientists to participate in their work and contribute data to the search for the complex set of causes for such strandings.

Mining Data for Connections

Mass strandings occur around the world and can affect anywhere from three to several hundred animals during any given event. Although they are a global phenomenon, scientists have identified certain hot spots: New Zealand, Australia, and Cape Cod, Massachusetts, all of which share key geographic characteristics like sloping beaches and fine-grained sediment—factors thought to play a role in strandings.

In strandings involving multiple deaths, autopsies reveal that the vast majority of the deceased animals were healthy before they beached. Some researchers hypothesize groups strand when their strong social bonds compel them to follow a distressed individual into shallow waters.

"Whales and dolphins have always been mythical emblems for us," said Desray Reeb, a marine biologist at BOEM's headquarters in Sterling, Virginia. "They're intelligent, social and mystical, and present an intriguing challenge for us to understand because they're so like us, and yet so different."

This particular investigation was Reeb's brainchild; she approached Pulkkinen about launching the research effort after hearing his presentation about space weather in June 2015. The team initially focused on Cape Cod—the biggest hot spot in the United States—and sifted through nearly two decades of IFAW stranding observations alongside both ground- and space-based NASA space weather data.

Just as weather varies on Earth, occasionally bringing thunderstorms and gusty winds, the ever-changing Sun sometimes hurls massive clouds of solar material and magnetic fields into space, called coronal mass ejections, or CMEs. The effects of these eruptions on near-Earth space are collectively known as space weather. CMEs can spark powerful geomagnetic storms if they slam into Earth's magnetic field. If solar storms and strandings were indeed connected, the scientists thought they might detect patterns in Earth's geomagnetic activity in the time

surrounding a stranding event.

"If we can determine what conditions promote strandings and develop an alert system that recognizes when those factors are coming together, then stranding networks in different areas can prepare for the event and get rescue efforts on the ground sooner," said project collaborator Katie Moore, the IFAW Deputy Vice President of Conservation and Animal Welfare.

Headquartered in Yarmouth Port, Massachusetts, IFAW operates in 40 countries, rescuing animals and promoting conservation to secure a safe habitat for wildlife. In Cape Cod, IFAW has developed a robust emergency response program that has increased the stranding survival rate from 14 to 75 percent in almost 30 years. Shifting from reactive to predictive capabilities, however, would represent an entirely new approach to animal rescue. With funding from BOEM's Environmental Studies Program and NASA's Science Innovation Fund, the team undertook a major data-mining effort to take the initial steps toward developing predictions.

First, they looked for correlations between each stranding event and the space weather outlook the day of that event. Then, they shifted the space weather data by different time periods—one day, two days, 10 days, and so on—to explore whether there is a delay in the effects of solar activity on strandings.

After analyzing all the data, the scientists found that no matter the shift in time, space weather had the same statistical relationship with each stranding—indicating no clear causal connection between geomagnetic activity and the Cape Cod strandings.

While the scientists had been hoping for a eureka moment, the results of their analysis still led them to consider that while space weather isn't a

primary driver of strandings, it could be one factor among several. Unraveling interactions and events in biological scenarios typically requires ecological perspectives; perhaps space weather, they thought, was one necessary component of the grander ecological conditions that lead to mass stranding events.

"Although our analyses indicated that geomagnetic storms are likely not a major cause, it is very difficult, if not impossible, to completely exclude any possible factor from the mix," Pulkkinen said. "Our view is that strandings are likely caused by a complex combination of multiple environmental factors, so we want to include the widest possible range of possible parameters in the follow-up study."

Expanding the Search

Diving deeper into the complex puzzle of mass strandings, the team decided to expand their analysis and include additional oceanographic and atmospheric data sets from NASA's Earth science missions, including Terra, the Sea-viewing Wide Field-of-view Sensor—or SeaWIFS, for short—and Global Precipitation Measurement, as well as the National Oceanic and Atmospheric Administration's Geostationary Operational Environmental Satellite, or GOES, mission. In turn, the team itself also expanded to include more collaborators with expertise in the increasingly complex statistical analysis the project demanded.

The additional data may shed light on the interacting conditions that affect cetaceans' behavior. For example, tides, winds and sea surface temperature could disrupt their migration habits, and ocean color—referring to the water's chemical and particle content—could reflect changes in the food chain.

"NASA has access to large-scale oceanographic data sets ranging from primary productivity to ocean temperature, currents and wind," Moore

said. "For the first time, we're layering huge data sets to study this problem. Maybe we'll find there's a 'perfect storm' of conditions that lead to a stranding."

To determine whether they've found a plausible explanation for a stranding, the team statisticians build models that attempt to make predictions within their data sets. They remove a small subset of the data, and if their model can accurately replicate the missing pieces, the scientists may be on the right track.

"These environmental and animal observations are noisy data, so whatever we find, we have to take with a grain of salt," said Erdem Karaköylü, a Goddard Earth science data analyst and oceanographer who joined the team during its expansion. "But it's also a rich data set. When you have a lot of data, it's easier to discard what's not useful."

While the team's initial attention is turned to Cape Cod, their research has implications for preventing strandings across the globe. According to Reeb, each stranding hot spot requires individualized study, but the factors affecting strandings may be the same globally—albeit to varying degrees of importance. Additionally, the team's current priority is laying the groundwork for future studies by developing methods for storing and analyzing multiple data sets. They envision building an open-source tool that would enable scientists across the world to collaborate and study strandings in their area in a similar fashion.

Moore is still hopeful that her team will one day have a predictive model to support their rescues, ultimately enabling them to save more animals. In the meantime, the team will continue to inspect the layers of data for interactions and patterns, deepening their understanding of mass strandings and setting a precedent for future interdisciplinary studies.

"In past decades, we scientists often have worked in isolation, everyone

sticking to their own specialty and answering questions from their perspective," Reeb said. "This exciting study brings amazing people with diverse expertise together to answer a question that has ramifications across the board."

For more information on the ongoing project, visit: http://spaceweathercenter.cua.edu/strandings-project.cfm

Provided by NASA's Goddard Space Flight Center