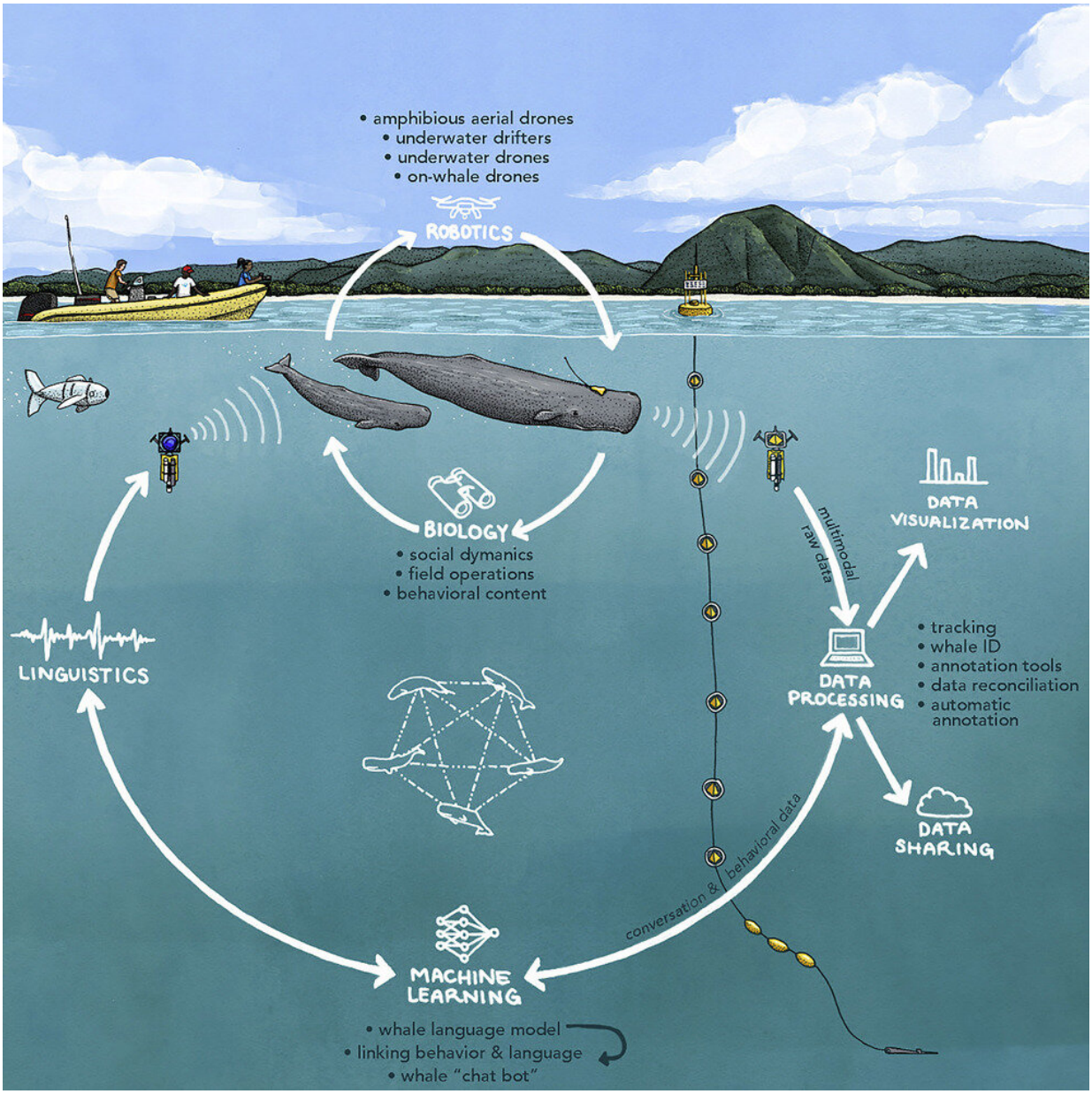
A race to converse with, and save, the ocean's brainiest eco-predators

July 15 2022, by Yasmin Anwar



Graphical abstract. Credit: *iScience* (2022). DOI: 10.1016/j.isci.2022.104393

In the 2016 sci-fi movie "Arrival," a linguist and a theoretical physicist race against time to communicate with endangered extraterrestrial heptapods wishing to share their wisdom and technologies with the human race so it will survive and one day return the favor.

At the University of California, Berkeley, a real and more down-to-earth mission to decode an unknown form of communication is underway. Linguist Gasper Begus and computer scientist Shafi Goldwasser are part of an international team of researchers attempting interspecies communication with sperm whales by deciphering their deafening, 200-plus decibel clicking sounds, or codas.

They are among the key members of the Cetacean Translation Initiative (CETI), a newly launched, five-year multidisciplinary project aimed at cracking sperm whales' Morse code-like communications off the Caribbean island of Dominica, to gain a deeper knowledge of the ocean's brainiest predators and to preserve their habitat from further human disruption.

With scientists from 16 different research enterprises, CETI is estimated to be the largest effort at interspecies communication in history. Whether on land or in the ocean, it is a daunting feat.

"We're dealing with a completely unknown form of communication, and gathering the data can be challenging," said Begus, an assistant professor of linguistics in UC Berkeley's Division of Social Sciences and director of the Berkeley Speech and Computation Lab. CETI's engineering team is building a system of drones that will automatically tag the whales and record their vocalizations and other parameters, such as orientation,

velocity and temperature.

Preceding humans on Earth by some 15 million years, sperm whales' gigantic brains give them the neural capacity for planning, sophisticated communication and social interactions that last for decades. Their silvery, 30-plus-ton bodies store carbons and play a supporting role in cooling the earth.

Sperm whales organize themselves into large, matrilineal families and clans, with each group identifying itself with its own signature dialect. Their powerful clicking sounds are emitted via a mixture of organs known as spermaceti that are atop their skulls. The whales' sound patterns are learned—not innate, like a dog's bark, Begus said.

Their deep-ocean habitats are threatened by noise pollution, climate change, commercial fishing and military activities that include underwater explosions and sonar technology.

If left to die naturally, sperm whales sink to the ocean floor, taking with them the carbons stored in their bodies that would otherwise have been released into the atmosphere if the whales had been hunted and brought to land. Moreover, whale excrement contributes to the growth of phytoplankton, which is estimated to capture some 40% of all carbon dioxide produced.

"If we get to know sperm whales better by learning their communication and the full scope of their cognitive and social life, it's harder for us as a species to treat them like non-sentient beings and destroy them," Begus said.

In their respective labs at UC Berkeley, Begus and Goldwasser, a winner of the prestigious Association for Computer Machinery's A.M. Turing Award, are using artificial intelligence, including deepfake technology,

to identify linguistic patterns in recordings of what may eventually amount to billions of sperm whale clicks.

"In the case of translation of one human language to another, a 'Rosetta stone' is often available, which makes this a so-called supervised language translation problem. And even when such examples are not known, at the very least we have a good sense of what may be the general topics and context in which conversations are taking place, so as to detect when a proposed translation is nonsensical," said Goldwasser, who at UC Berkeley is director of the Simons Institute for the Theory of Computing and the C. Lester Hogan Professor in Electrical Engineering and Computer Sciences.

"For CETI," she added, "we need to significantly extend the theory and practice of unsupervised language translation, where no correct translation examples are given, to a setting where our prior knowledge on what the whales may be communicating about is limited, and we can't run controlled experiments. New methods to model what the whales are communicating about will guide us when we are making progress in the translation task or, alternately, rule out proposed translations."

As with any unknown form of communication, the sounds sperm whales make to communicate with one another and navigate via echolocation are full of enigmas. The unknown in the sperm whale communication system is not only what the codas mean, but also how we test and confirm what we think they mean.

To tackle these questions, the team will take advantage of new advances in artificial intelligence (AI). Begus is developing AI models that learn human speech in a way that is similar to how children learn language: without supervision, without text, and by imitation and imagination. Together with his team in the Berkeley Speech and Computation Lab, he is testing whether models that learn human language from speech can

also learn the sperm whale communication system.

Meanwhile, fellow CETI collaborators from more than a dozen research institutions worldwide are working on other areas of the project, including the installation of a network of underwater microphones, drones and robotic fish to stealthily track and record sperm whale communication.

CETI's leader, David Gruber, is a professor of biology and environmental science at Baruch College at the City University of New York. Gruber, Goldwasser and Michael Bronstein, a professor of computer science and artificial intelligence at Oxford University, met in 2018 during a fellowship year at Radcliffe College. There, they came up with CETI's goal during a yearlong seminar that examined many possible ways to use machine learning in the sciences.

Their research is published in *iScience*. Other project collaborators hail from MIT, Harvard University, Israel's Haifa University, Canada's Carleton University, Aarhus University in Denmark, University of Lugano in Switzerland, Google Research, the Dominica Sperm Whale Project and Italy's Institute for Scientific Interchange.

The Save the Whales movement dates back to the 1960s when American biologist Roger Payne, now a member of CETI, recorded "Songs of the Humpback Whale," which led in 1972 to the federal Marine Mammal Protection Act. The act prohibits activities that harass, capture, collect or kill marine mammals, such as whales, dolphins, seals and manatees.

More information: Jacob Andreas et al, Toward understanding the communication in sperm whales, *iScience* (2022). DOI: 10.1016/j.isci.2022.104393

Provided by University of California