© 2022. Published by The Company of Biologists Ltd | Journal of Experimental Biology (2022) 225, jeb244075. doi:10.1242/jeb.244075

INSIDE JEB

Gargantuan whales more manoeuvrable than they ought to be

Two humpbacks wearing suction-cup-attached trackers manoeuvre in Antarctic waters. Photo credit: K. C. Bierlich.

A fighter pilot wouldn't enter into a dogfight in a Boeing 747. They'd opt for something more nimble, like a Eurofighter Typhoon or Lockheed Raptor. But immense baleen whales don't have the privilege of shrinking to pursue the smallest and quickest fish and krill to dine upon. Yet somehow, they manage to overwhelm their agile victims. The irony is that the massive mammals only became so large because they could capture colossal quantities of food in a single gulp. So just how manoeuvrable are these extraordinary creatures, and how does that versatility vary from the relatively diminutive minke whales (5.0 m, 2000 kg) to the truly gargantuan blue whales (30 m, 185,000 kg)? Over the past 10 years, Jeremy Goldbogen's lab at Stanford University, USA, has built up an extensive network of 25 collaborators from all across the USA, Greenland, Denmark, The Netherlands, South Africa and the Falkland Islands, attaching movement sensors with magnetometers and depth gauges to 280 whales – including minke, Bryde's, grey, humpback, sei, fin and blue whales – to find out how their movements varied from the smallest to the largest.

Describing the experience of tagging a whale, Paolo Segre (Stanford University) says, 'It's incredible. As they rise out of the water, you realize how large they are'. And retrieving the sensitive tags is every bit as nerve-wracking. 'When you throw something delicate and expensive into the ocean, there's a reasonable chance that you won't get it back, so every time we recover a tag it's a big deal', he smiles. In addition, the team took aerial photographs of 93 animals to calculate their sizes.

After successfully collating 4037 h of whale movements over a 10-year period, Segre recalls analysing the daunting dataset, breaking the movements down into fast sprints, flips and somersaults, rolls and turns, while also calculating the whales' swimming speeds. After months of painstaking calculation, Segre eventually identified over 625,000 manoeuvres before plotting the accelerations experienced by the animals against their masses to find out which whales were the most and least manoeuvrable.

Not surprisingly, the blue whales were the most cumbersome, manoeuvring more slowly than the smaller and more sprightly species. However, when the team compared the blue whale's movements with their expectations – based on the animals' colossal size – they found that the blue whales were accelerating faster than had been thought possible. And, when they checked the turn speeds and somersault accelerations of the other large whales, they saw that these animals were also outperforming the scientists' expectations. The largest whales seemed to be depending on their flippers and spines – which bend and arch – to accelerate their flips, while using their flippers like aeroplane wings to compensate for their size and turn faster.

Segre's analysis also showed that the humpbacks' scalloped flippers helped them to roll faster than the other species. However, slow-moving grey whales, which roll onto their sides to suck food from the bottom of shallow inlets, depended on their flukes (tail fins) to tip over onto their sides, tucking their flippers against their bodies. And the humpbacks, which dine on nimble krill, were more lithe, surging and tumbling faster than the whales that feast on fish, suggesting that diet influences the animals' manoeuvrability.

So larger baleen whale species are less agile than their smaller cousins, but blue whales and fin whales are more agile than they should be for their size, taking advantage of their flippers and flukes for harder turns and flips than might otherwise be possible. 'Large whales play to their strengths to overcome the limitations of their body size', says Segre.

10.1242/jeb.244075

Segre, P. S., Gough, W. T., Roualdes, E. A., Cade, D. E., Czapanskiy, M. F., Fahlbusch, J., Kahane-Rapport, S. R., Oestreich, W. K., Bejder, L., Bierlich, K. C. et al. (2022). Scaling of maneuvering performance in baleen whales: larger whales outperform expectations. *J. Exp. Biol.* **225**, jeb243224. doi:10.1242/jeb.243224

Kathryn Knight
kathryn.knight@biologists.com