INSIDE JEB

# Minke whales lunge to feed under sea ice

Tagged minke whale about to dive beneath sea ice. Photo credit: Ari Friedlaender under NMFS permit 14097 and ACA permit 2012-014.

Highly manoeuvrable and built like torpedoes, minke whales are the most common whales in Antarctic waters, yet the animals could be living on a knife edge as their sea-ice homes dwindle rapidly. 'Sea ice in the area around the Antarctic Peninsula has decreased dramatically in the last 30 years,' warns Ari Friedlaender from Oregon State University, USA, 'yet we do not know how critical the sea ice is as a habitat for the whales.' Given the pressing need to understand what the whales require to survive in their challenging and changing environment, Friedlaender and colleagues from the Southern Ocean Research Partnership – an international group of researchers dedicated to non-lethal whale research – headed south to tag minke whales in their Antarctic home to find out more about their lifestyle (p. 2851).

However, tagging a minke whale is much trickier than tagging other species that inhabit the icy waters. 'Minke whales are fast moving and they don't spend a lot of time at the surface', says Friedlaender. However, when Nick Gales, Doug Nowacek, Andy Read and Friedlaender encountered a pod of 35–40 minke whales in the Antarctic's Wilhelmina Bay, the team's luck was in. 'We very rarely see these large groups, so we knew that this was an extraordinary case', says Friedlaender. He recalls that the whales appeared to be socialising and were distracted from the scientists, which allowed them to manoeuvre the boat gently in amongst the animals. Describing how he took his chance to land the tag on a whale's back just as the animal descended beneath a chunk of ice, Friedlaender chuckles and says, 'It was a textbook delivery.' But then he recalls the next nail-biting 3 minutes while the team waited for the whale to resurface. 'We realised that we had just put a $25K tag on an animal that went under the ice and if it fell off there we were never getting it back', he laughs. Fortunately, the tag stayed in place for an incredible 19 h, and when the team successfully tagged another whale a few days later, they were able to collect a further 8 h of precious dive data.

Teaming up with Jeremy Goldbogen and Dave Johnston to analyse the whales' orientation, depth and acceleration – which showed when the whales lunged to engulf mouthfuls of krill – Friedlaender could see that the minkes' behaviour was very different from that of other whales. Blue whales lunge up to four times during a dive and smaller humpbacks lunge up to 12 times per dive, so Friedlaender and his colleagues were astounded to see the minke whales lunging as many as 24 times during a single dive. 'They lunge over 100 times an hour, almost once every 30 seconds', marvels Friedlaender. And when the trio analysed the dive patterns, they realised that the whales have three different strategies.

Friedlaender explains that the first two types of dive looked like classic whale dives. In the first, the animals remained near the surface and lunged one to two times, while in the second dive type the whales plummeted to depths of 100 m and lunged about 15 times. However, when they analysed the third type of dive, they realised that it was completely unique. The whales were swimming just beneath the surface of the water and were feeding at incredibly high rates. And when the team checked the locations of the dives they realised that the whales were skimming the underside of the ice. 'The whales were feeding just underneath the surface where the sea ice meets the water and where the krill were aggregating', says Friedlaender.

Having proved that it is not necessary to kill whales to understand their feeding behaviour, Friedlaender and his colleagues are keen to return to tag more minke whales to learn more about how the animals interact with their surroundings. 'Tagging opens up a huge window of opportunity to study the Antarctica ecosystem in a much more holistic way', says Friedlaender.

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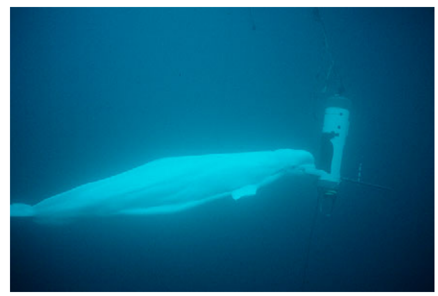
**Friedlaender, A. S., Goldbogen, J. A., Nowacek, D. P., Read, A. J., Johnston, D. and Gales, N.** (2014). Feeding rates and under-ice foraging strategies of the smallest lunge filter feeder, the Antarctic minke whale (*Balaenoptera bonaerensis*). *J. Exp. Biol.* **217**, 2851-2854.

**Kathryn Knight**

# Cetaceans squeal with delight



Whale responding to sound signal underwater. Photo credit: US Navy.

Sam Ridgway has spent most of his life learning about dolphins and whales. Over his five-decade career he has asked these cetaceans various questions, including how deep they can dive and how depth affects their hearing. As he trained each animal to answer his questions, he rewarded them with tasty fish treats, and each time that they received a reward he remembers that they squealed. Initially he thought that the squeals were food signals, where animals communicate the presence of food to nearby members of their species. It was only when his wife Jeanette suggested that the squeals reminded her of delighted children that he began to ponder whether there was more to the cetaceans' cries: could they be genuine expressions of delight? (p. 2910).

Humans train animals by rewarding them with tasty treats and trainers couple the reward with a sound, such as a buzz or a

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whistle. Once the animal has mastered the task, the trainer stops dispensing food, relying instead on the whistle or buzzer to inform the animal that it has performed successfully and that it will be rewarded with food later. What impressed Ridgway was that even though there was no food reward at the time, the whales and dolphins squealed in response to the sound that substituted for the food reward. And when he trained dolphins and beluga whales to switch off a sound after diving hundreds of metres, Ridgway was impressed that the animals produced the same squeals of victory when the sound stopped. 'The [squealing] behaviour had transferred over to another stimulus that wasn't food', says Ridgway. The behaviour also reminded him of studies in the 1950s when animals appeared to derive as much pleasure from electrical stimulation of a region of the brain that released dopamine – a chemical that stimulates the sensation of pleasure – as they did when receiving a food reward. Had the trained dolphins and beluga whales transferred the release of dopamine from the brain's pleasure centres from the food reward to the trainer's reward signal?

Delving back through decades of recordings of experiments designed to test the abilities of dolphins and beluga whales that he had conducted with Patrick Moore, Don Carder and Tracy Romano, Ridgway then measured the delay between the trainer's signal and the victory squeals. As dopamine release takes 100–200 ms, Ridgway realised that the animals could be expressing pleasure if the delay between the promise of a reward and the animals' squeals was longer then the dopamine release period.

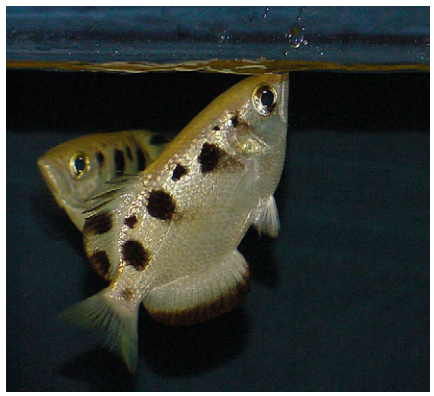
'Normally we worked in open waters in the San Diego Bay or out in the ocean… Our recordings sometimes have a lot of background noise, so most of the analysis has to be done by hand using the human ear', recalls Ridgway. However, after months of painstaking analysis, Ridgway was convinced that the beluga whales and dolphins were expressing pleasure through their squeals. 'The dolphins take an average of 151 ms extra time for this release, and with the belugas…it's about 250 ms delay', says Ridgway. He concludes with a smile, 'We think we have demonstrated that it [the victory squeal] has emotional content', before adding that he is keen to find out more about the cognitive abilities of these expressive animals.

doi:10.1242/jeb.111559

**Ridgway, S. H., Moore, P. W., Carder, D. A. and Romano, T. A.** (2014). Forward shift of feeding buzz components of dolphins and belugas during associative learning reveals a likely connection to reward expectation, pleasure and brain dopamine activation. *J. Exp. Biol.* **217**, 2910-2919.

**Kathryn Knight**

## Archerfish C-start to intercept falling flies



Archerfish, *Toxotes chatareus*. Photo credit: Volker Runkel.

Being knocked off your perch by a jet of water may not be a dignified death, but it is an effective way for an archerfish to secure lunch. However, once an insect has been dislodged, the race to be first at the landing site is on, leaving little time for archerfish to select an approach strategy. Caroline Reinel and Stefan Schuster from the University of Bayreuth, Germany, explain that many fish use a specialised response to escape predators – they curl their bodies into a C shape before beating the tail hard to flee – and archerfish seem to use the same strategy to ensure their speedy arrival when the fly splashes down (p. 2866). However, it wasn't clear whether the C-start alone was sufficient to set the fish off at the optimal speed to intercept a falling fly, or whether it was necessary for the fish to fine-tune their approach with fin beats to optimise the retrieval trajectory.

Intrigued, Reinel and Schuster began investigating the fish's pursuit strategy. Firing dead flies off a platform above a tank of water with a puff of air in random directions and from various heights, the duo filmed the reactions of the fish residents at high speed to capture every detail of the victor's departure as they competed to reach the tasty morsel. Then, having selected 306 unambiguous fly intercepts, Reinel focused on the manoeuvres of the first fish to arrive at the landing site, and painstakingly analysed the first 40 ms of the winner's departure.

After measuring the angle of each fish as they pushed off from the C-start, Reinel could see that the winner had already set the correct bearings toward the flies' future impact sites when they set off. Then she analysed the progress of the fishes' snouts in 10 ms intervals as they swam toward the fly and was impressed to see that the first fish had already reached the optimal speed to beat the others to the landing site during the first 10 ms after uncoiling. Explaining that hunting archerfish already know how far their quarry have to fall – because they have to know the height of the fly to successfully knock it off its perch – Schuster adds that the fish are able to use this information, coupled with a glimpse of the fly's descent, to set the speed at which they must travel to ensure interception. However, once they have unleashed the C-start, the fish do not adjust their speed during the early stages of pursuit, although Schuster notes that this does not preclude the fish from adding a final burst of acceleration to outcompete other fish as they converge on the hapless fly. He was also impressed that the fish seemed to be able to take into account the amount of time that it takes for them to trigger a C-start, which reduces the time that they have to home in on the fly and forces them to swim faster.

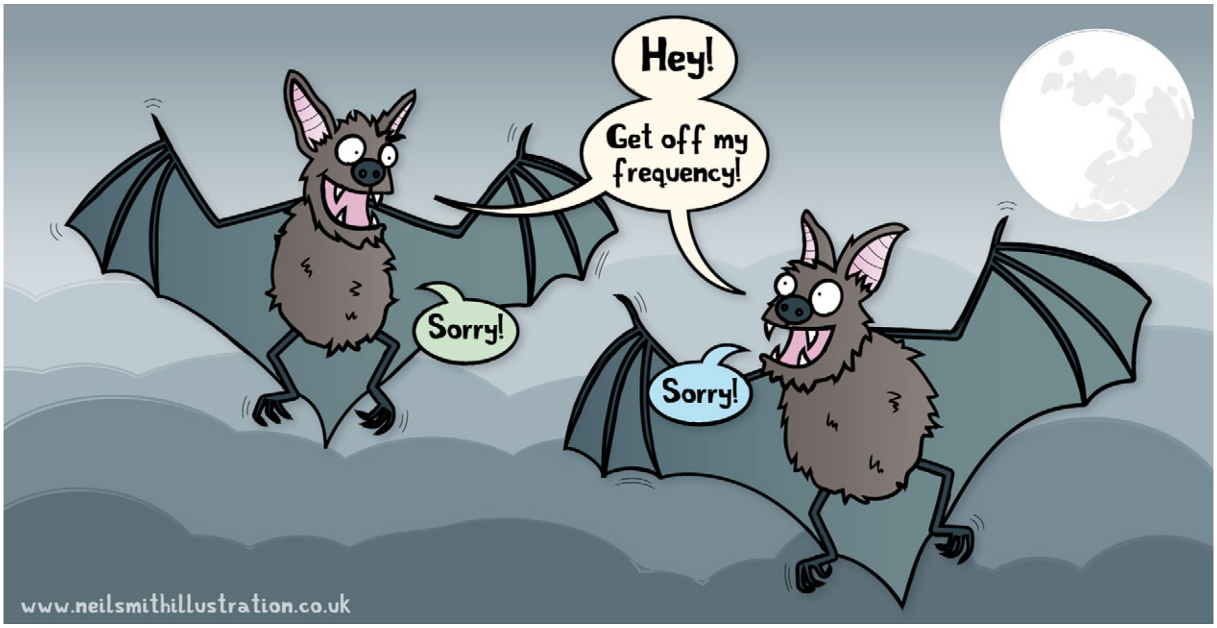
Having shown that the archerfish's C-start is extraordinarily adaptable, allowing hungry fish to select an accurate intercept course during the victim's descent, Schuster suspects that the fish could help us to learn more about the process of making a decision. 'The underlying circuitry would be the ideal substrate to study fundamental aspects of decision-making', says Schuster.

doi:10.1242/jeb.111534

**Reinel, C. and Schuster, S.** (2014). Pre-start timing information is used to set final linear speed in a C-start manoeuvre. *J. Exp. Biol.* **217**, 2866-2875.

**Kathryn Knight**

# Bats shift shrieks to avoid jamming




As if it's not enough of a problem for echolocating bats to disentangle echoes from leaves and other surrounding clutter, they also have to worry about interference and jamming from the echolocation calls of other bats in the vicinity. Shizuko Hiryu and her students, Eri Takahashi and Kiri Hyomoto from Doshisha University, Japan, explain that bats must be able to prevent the echolocation calls of nearby bats from jamming their own calls, but it wasn't clear exactly how they modulate their own echolocation shrieks to avoid interference. 'Doppler-induced error [where the frequency of a call is altered by the animal's own movements] makes it difficult to obtain accurate measurements of echolocation pulses from bats in flight', Hiryu says. However, this technical challenge didn't disconcert the team. Instead, they constructed minute (0.6 g) microphones that they could mount on the backs of tiny (5–10 g) Japanese house bats to record the minuscule aviators' shrieks as the scientists exposed the animals to simulated jamming calls during flight to find out how the bats adjusted their calls to overcome the interference (p. 2885).

They discovered that in addition to shifting the frequency of their calls when they overlapped with the jamming sounds, the bats also shifted the calls so that they were out of synch with the simulated jamming shrieks. 'Our findings demonstrate that bats could adjust their vocalized frequency and emission timing during flight in response to acoustic jamming stimuli', says the team.

doi:10.1242/jeb.111542

**Takahashi, E. and Hyomoto, K., Riquimaroux, H., Watanabe, Y., Ohta, T. and Hiryu, S.** (2014). Adaptive changes in echolocation sounds by *Pipistrellus abramus* in response to artificial jamming sounds. *J. Exp. Biol.* **217**, 2885-2891.

**Kathryn Knight**
**kathryn@biologists.com**