Animal navigation: Jellyfish dodge the drift

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Orientation in the ocean can be challenging because of a lack of landmarks. Evidence is accumulating that jellyfish, once considered to be passive drifters, can also show directional swimming to avoid stranding ashore, using ocean waves for orientation, just like hatchling turtles.

"If the pilot misses Ascension, his wife gets a pension" — this old rhyme comes from the early days of flights to Ascension Island during and after World War II. Ascension is an isolated speck in the middle of the equatorial Atlantic thousands of kilometres from land. Accurate navigation and orientation can be a matter of life and death not just for pilots but also for many animals needing to navigate and orientate to help their survival (Figure 1). Indeed, like pilots, green turtles face the navigational challenge of migrating to Ascension Island to breed and nest, travelling from their remote foraging grounds on the Brazilian coast, a feat that has astounded biologists for more than a century, including Charles Darwin[1]. Particularly challenging are feats of navigation and orientation where there appear to be no clear signposts. On land, animals use landmarks to find their way. However, in the ocean, visual cues are often lacking, for example in deep water far from land. Also invertebrates with no sight still somehow navigate in the oceans. How marine taxa orientate remains an enduring mystery. For sea turtles and other vertebrates, including marine mammals and birds, high-resolution tracking is revealing the intricate details of the routes that individuals follow on their journeys, shedding new light on their navigation performance[2]. Tracking marine invertebrates is much less developed, but a new study by Dror Malul, Yoav Lehahn and colleagues[3] in this issue of *Current Biology* uses a series of elegant approaches to uncover a remarkable feat of orientation by a relatively poorly studied group, jellyfish.

The distribution, abundance and ecology of jellyfish tend to be less well known than those of many other marine species. Yet there is growing interest in the biology of jellyfish because they may play important ecosystem roles, negatively impact fisheries and aquaculture[4,5] and in some areas may be increasing in abundance, sometimes termed the 'rise of slime'. Due to their low energy content, jellyfish were once considered to be 'trophic dead-ends', i.e. something that very few other animals fed on. However, this view has now been overturned, and a broad range of animals, including marine birds, fish, sea turtles and various invertebrates are now known to consume jellyfish[4]. The growing appreciation of the ecosystem role of jellyfish has been accompanied by the development of new methods for their study. For many decades it has been known that the direction of travel of large jellyfish can be recorded through direct observation from boats[6]. Then, about 20 years ago, it was shown that some species of jellyfish could be viewed and identified with low flying aerial surveys, providing new insights into their distribution[7]. A decade later, it was shown that individuals could be directly tracked with electronic tags (Figure 1)[8]. These types of studies started to reveal that some species of jellyfish are strong swimmers and can actively search the water column for prey with the same patterns of prey search seen in fish[9] (Figure 1), overturning the traditional view that jellyfish are simply passive drifters.

Now, Malul and colleagues[3] have completed an elegant study where they have built on, and extended, these approaches to provide new insights into

Figure 1. Animal orientation and navigation across diverse taxa.
(Top left) Green turtles can travel thousands of kilometres across oceans to breed on small, remote islands. How they find such remote targets has perplexed biologists, including Charles Darwin, for more than a century. Pictured is a pair of mating green turtles washed ashore in the Chagos Archipelago, a remote turtle breeding site in the middle of the Indian Ocean to which turtles migrate from 1,000s of km away. (Bottom left) Jellyfish swimming can be assessed through electronic tracking and direct observation from boats or drones. Pictured is a *Rhizostoma* jellyfish equipped with a depth sensing tag. (Right) Some jellyfish are large and can swim strongly so that they do not simply drift with currents. Pictured is part of a *Rhizostoma* jellyfish. This jellyfish is shown without the swimming bell, so that it could be lifted for the photo (photo: Tom Doyle).

directional swimming by jellyfish and the cues they use to orientate. Working with a large species of jellyfish in the eastern Mediterranean, *Rhopilema nomadica*, they used drones to record the swimming direction of thousands of jellyfish swimming near the surface. Drones are now widely used in wildlife biology, including with various marine species[10]. Malul and colleagues[3] came up with the innovative approach of hovering a drone over a bloom of *Rhopilema* and then using frame-by-frame analysis of the drone footage to generate a track of individual jellyfish. Most jellyfish were seen swimming on their side, i.e. they were not just drifting. This was the first surprise. The second surprise was that, remarkably, most jellyfish were swimming in the same direction — the entire swarm was heading the same way. This consistent movement suggested that the jellyfish might be using a common cue to orientate, but what might that cue be? Certainly the jellyfish were not using visual landmarks such as land or the seabed, as this species has no eyes. When the direction of surface waves was examined, a clear pattern was found: almost all jellyfish were swimming into the oncoming waves. Waves generally approach parallel to shorelines and so swimming into waves will usually lead an animal offshore. In the case of jellyfish, this directional swimming will reduce the risk of individuals stranding. Interestingly, some other animals are known to use waves to orientate. Hatchling turtles emerging from their nests crawl down the beach to the sea and then travel offshore by swimming directly into oncoming waves[11], taking them offshore and away from near-shore areas full of predators. So the picture that has emerged is that widely different taxa, jellyfish and turtles, can use the common cue of wave direction to orientate.

Hatchling turtles are thought to perceive the wave direction by the circular body acceleration they experience as the wave passes. Exactly how jellyfish perceive wave direction is unknown but might involve a similar process. Jellyfish have organs in their swimming bell called statocysts that serve as their balance organs, akin to the human inner ear. The jellyfish statocysts are likely to be involved in perceiving wave direction. Hatchling turtles can struggle to find their way offshore in glassy calm conditions because then they do not experience the orientation cue from waves. So an intriguing question is what *Rhopilema* jellyfish would do in these circumstances — perhaps then different individuals would not show the same direction of swimming and the jellyfish would swim haphazardly? A challenge now is to identify how broadly the findings of Malul and colleagues[3] apply to other species of jellyfish which live in a broad range of environments and so might be expected to use a range of cues to orientate. For example, in some coastal bays and inlets jellyfish not only risk being stranded ashore but can also be washed out to sea and away from their preferred habitat. Under such circumstances, jellyfish might orientate with respect to surface currents which may flow in different directions to the wave movement[8]. There is also a myriad of smaller species of jellyfish that will have a weaker swimming ability than large *Rhopilema*. For example, small moon jellyfish, *Aurelia aurelia*, often dominate in coastal temperate areas while the small bioluminescent jellyfish *Pelagia noctiliuca* is generally found further from land. Both species can aggregate and form dense swarms, but what cues are they using to orient? Whether these smaller jellyfish can actively swim to influence their movements remains an open question.

But why should we care about how jellyfish orientate and move in the world's oceans? A better understanding of what drives the movements of jellyfish might help to mitigate their various negative impacts. Millions of jellyfish may sometimes occur in big aggregations and swarms of jellyfish have caused massive fish kills. For example, a swarm of *Pelagia noctiluca* killed ∼250,000 salmon in a Northern Island fish farm[12], prompting questions in the UK Parliament about how the threats of jellyfish could be reduced. Swarms of jellyfish have clogged cooling water intakes causing power stations to stop functioning, have burst fishermen's nets and stinging jellyfish have closed tourist beaches. Being able to predict how jellyfish move may help mitigate these impacts. The study of Malul and colleagues[3] shows that tracking the movement of jellyfish is now possible with relatively simple tools, opening the way for this work to be extended across oceans and for different species.

DECLARATION OF INTERESTS

The author declares no competing interests.

REFERENCES

1. Darwin, C. (1873). Perception in the lower animals. Nature *7*, 360.
2. Hays, G.C., Cerritelli, G., Esteban, N., Rattray, A., and Luschi, P. (2020). Open ocean reorientation and challenges of island finding by sea turtles during long-distance migration. Curr. Biol. *30*, 3236–3242.
3. Malul, D., Berman, H., Solodoch, A., Tal, O., Barak, N., Mizrahi, G., Berenshtein, I., Toledo, Y., Lotan, T., Sher, D., *et al*. (2024). Directional swimming patterns in jellyfish aggregations. Curr. Biol. *34*, 4033–4038.e5.
4. Hays, G.C., Doyle, T.K., and Houghton, J.D.R. (2018). A paradigm shift in the trophic importance of jellyfish. Trends Ecol. Evol. *11*, 874–884.
5. Bosch-Belmar, M., Milisenda, G., Basso, L., Doyle, T.K., Leone, A., and Piraino, S. (2020). Jellyfish impacts on marine aquaculture and fisheries. Rev. Fish. Sci. Aquac. *29*, 242–259.
6. Shanks, A.L., and Graham, W.M. (1987). Orientated swimming in the jellyfish *Stomolopus meleagris* L. Agassiz (Scyphozoan: Rhizostomida). J. Exp. Mar. Biol. Ecol. *108*, 159–169.
7. Houghton, J.D.R., Doyle, T., Davenport, J., and Hays, G.C. (2006). Developing a simple, rapid method for identifying and monitoring jellyfish aggregations from the air. Mar. Ecol. Prog. Ser. *314*, 159–170.
8. Fossette, S., Gleiss, A.C., Chalumeau, J., Bastian, T., Armstrong, C.D., Vandenabeele, S., Karpytchev, M., and Hays, G.C. (2015). Current-oriented swimming by jellyfish and its role in bloom maintenance. Curr. Biol. *25*, 342–347.
9. Hays, G.C., Bastian, T., Doyle, T.K., Fossette, S., Gleiss, A.C., Gravenor, M.B., Hobson, V.J., Humphries, N.E., Lilley, M.K.S., Pade, N.G., and Sims, D.W. (2012). High activity and Lévy searches: jellyfish can search the water column like fish. Proc. R. Soc. Lond. B *279*, 465–473.
10. Schofield, G., Esteban, N., Katselidis, K.A., and Hays, G.C. (2019). Drones for research on sea turtles and other marine vertebrates — A review. Biol. Conserv. *238*, 108214.
11. Lohmann, K.J., and Lohmann, C.M.F. (1992). Orientation to oceanic waves by green turtle hatchlings. J. Exp. Biol. *171*, 1–13.
12. Doyle, T.K., Haas, H.D., Cotton, D., Dorschel, B., Cummins, V., Houghton, J.D.R., Davenport, J., and Hays, G.C. (2008). Widespread occurrence of the jellyfish *Pelagia noctiluca* in Irish coastal and shelf waters. J. Plankt. Res. *30*, 963–968.