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could apply to sensory processing in all animals (such as you and me).

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Boxfish don't swim the straight and narrow

Agile though awkward looking, coral reef-dwelling boxfish are aptly named for their unusual box-like shape, which is made up of many fused bony plates. This boxy shell, along with the toxins some boxfish secrete, works well as a defense against predation. However, the shell prevents movement of the body during swimming. So when you think of sleek, high performance fish that might be used as bioengineering models for vehicles, boxfish may not be the first that come to mind. However, previous research has shown that when boxfish swim, water moving around the body of the fish stabilizes the fish and keeps it moving forward in a straight path. The body shape was also shown to reduce drag during swimming. The stabilizing and drag-reducing effects of the body shape found in these studies inspired a model car design. But boxfish are highly maneuverable and being persistently forwardly stabilized by the water while swimming would make turning as quickly and easily as they do in their complex habitat difficult – hence, the boxfish paradox.

Sam Van Wassenbergh, at the University of Antwerp, Belgium, and his team of international collaborators set out to resolve this paradox using computer and physical models of two species of boxfishes. The authors first made three-dimensional surface laser scans of two boxfish specimens, *Rhinesomus triqueter* and *Ostracion cubicus*, representing the two extreme shapes of boxfish: triangular and cubic. They then removed the fins and estimated the center of mass for both specimens, to ensure the experimental models would twist, turn, pitch up or down, or stabilize in reaction to the water as the fish would naturally. Lastly, the authors made three-dimensional printed models of the specimens to test drag force and the effect of fluid speed on left and right movement (yaw) of the models in a flow tank.

The authors found that, contrary to early studies, water flowing over both fish shapes was destabilizing, not stabilizing. These results occurred over a range of swimming speeds. Neither the triangular nor cubic fish shape produced the forward stabilizing effect observed before. In addition, the boxfish had greater drag than other fish shapes, though less than an actual box, also contradicting previous findings.

With these results, the authors were able to resolve the paradox. Water flowing against the boxy fish exterior while they swim causes the fish to tilt and turn – instead of staying on a steady course – which aids maneuverability. The authors also suggest that fins play an important role in the skilled maneuvering of these fish and may be used for added stabilization. Van Wassenbergh and his group conclude that it's the independent actions of these smaller, active body parts that are key to the impressive aquatic performance of the boxfish.

Although the ridged form and shape of the boxfishes may not work well for straight, long distance swimming – or for cars – it does suit the needs of these fish in their natural habitat, where they must make quick, sharp turns to forage and escape predators. So as long as these fish limit their time swimming along the straight and narrow, the energetic costs of trying to maintain forward stability will be low. And car manufacturers may have to turn to other aquatic residents for high performance inspiration in the future – a shark-car perhaps?

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