Scientists put ichthyosaurs in virtual water tanks

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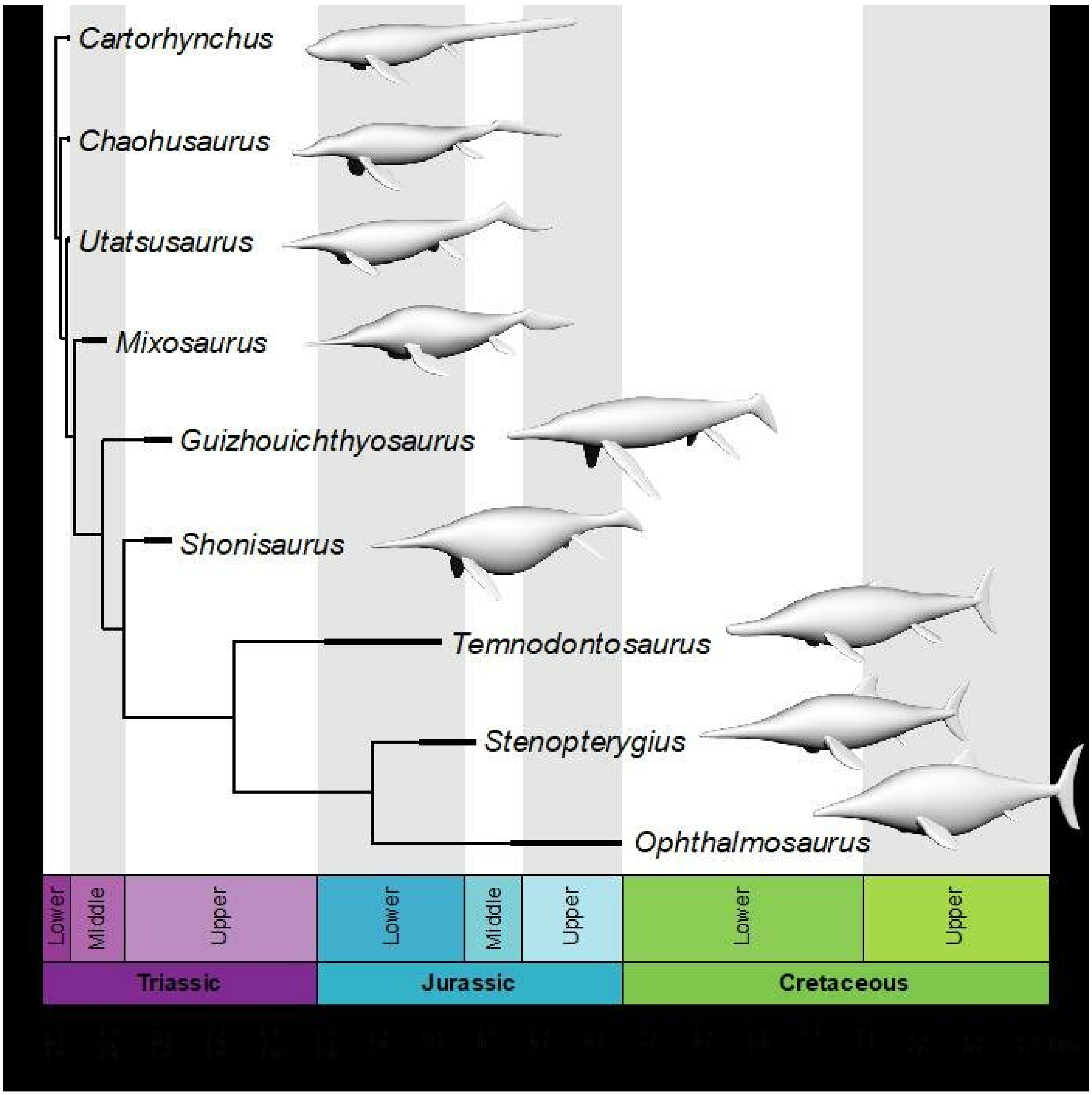


3D models of the nine ichthyosaurs analyzed by the researchers, shown in their evolutionary context. Credit: Gutarra et al., 2019)

Using computer simulations and 3-D models, palaeontologists from the University of Bristol have uncovered more detail on how Mesozoic sea dragons swam.

The research, published today in the journal *Proceedings of the Royal Society B*, sheds new light on their energy demands while swimming, showing that even the first ichthyosaurs had body shapes well adapted to minimise resistance and maximise volume, in a similar way to modern dolphins.

Ichthyosaurs are an extinct group of sea-going reptiles that lived during the Mesozoic Era, around 248-93.9 million years ago.

During their evolution, they changed shape substantially, from having narrow, lizard-like bodies to more streamlined fish-shaped bodies.

It was assumed that the change in body shape made them more efficient swimmers, especially by reducing the drag of the body, in other words, the resistance to movement.

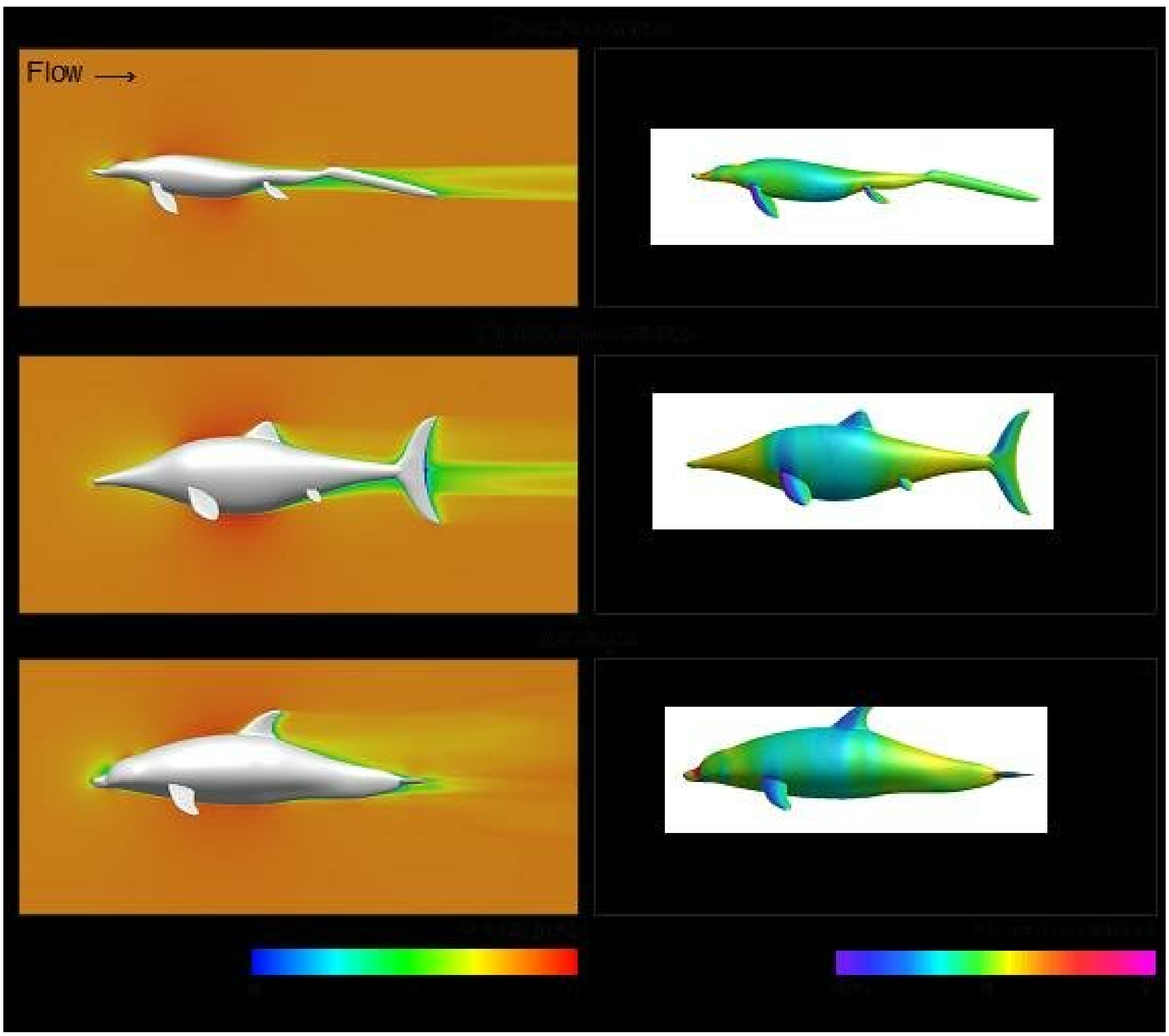
If they could produce less resistance for a given body mass, they would have more power for swimming, or swimming would take less effort. Then they could swim longer distances or reach faster speeds.

Susana Gutarra, a Ph.D. student in palaeobiology at the University of Bristol's School of Earth Sciences, said: "To test whether fish-shaped bodies helped ichthyosaurs reduce the energy demands of swimming, we made 3-D models of several different ichthyosaurs.

"We also created a model of a bottlenose dolphin, a living species which can be observed in the wild, so we could test if the method worked."

Dr. Colin Palmer, a hydrodynamics expert and a collaborator, added: "Susana used classic methods from ship design to test these ancient reptiles.

"The software builds a "virtual water tank" where we can control variables like the temperature, density and speed or water, and that allow us to measure all resulting forces.



Computational simulation of flow over the 3D models of two ichthyosaurs and a bottlenose dolphin. Velocity plot (left) and pressure coefficient (right) for a primitive ichthyosaur (*Chaohusaurus*), a derived fish-shaped ichthyosaur (*Ophthalmosaurus*) and a modern bottlenose dolphin (*Tursiops*). Credit: Susana Gutarra, University of Bristol

"The model ichthyosaurs were put into this "tank", and fluid flow conditions modelled, in the same way ship designers test different hull shapes to minimize drag and improve performance."

Professor Mike Benton, also from Bristol's School of Earth Sciences and a collaborator, said: "Much to our surprise, we found that the drastic changes to ichthyosaur body shape through millions of years did not really reduce drag very much.

"All of them had low-drag designs, and body shape must have changed from long and slender to dolphin-like for another reason. It seems that body size mattered as well."

Susana Gutarra added: "The first ichthyosaurs were quite small, about the size of an otter, and later ones reached sizes of 5-20 metres in length.

"When we measured flow over different body shapes at different sizes, we found that large bodies reduced the mass-specific energy demands of steady swimming."

Dr. Benjamin Moon, another collaborator from Bristol's School of Earth Sciences, said: "There was a shift in swimming style during ichthyosaur evolution. The most primitive ichthyosaurs swam by body undulations and later on they acquired broad tails for swimming by beating their tails (more efficient for fast and sustained swimming).

However, we found that some very early ichthyosaurs, like *Utatsusaurus*, might have been well suited for endurance swimming thanks to their large size, in spite of swimming by body undulations. Our results provide a very interesting insight into the ecology of ichthyosaurs."

Susana Gutarra concluded: "Swimming is a very complex phenomenon and there are some aspects of it that are particularly hard to test in fossil animals, like motion.

"In the future, we'll probably see simulations of ichthyosaurs moving through water.

"At the moment, simulating the ichthyosaurs in a static gliding position, enables us to focus our study on the morphology, minimizing our assumptions about their motion and also allow us to compare a relatively large sample of models."

More information: Effects of body plan evolution on the hydrodynamic drag and energy requirements of swimming in ichthyosaurs, *Proceedings of the Royal Society B*, rspb.royalsocietypublishing.or … .1098/rspb.2018.2786

Provided by University of Bristol