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PLESIOSAUR SWIMMING RECONSTRUCTED FROM SKELETAL ANALYSIS AND EXPERIMENTAL RESULTS

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Three basic hypotheses have been proposed for the swimming locomotion of plesiosaurs: rowing motion in which the flippers move primarily in a horizontal plane; figure-eight motion (underwater flight) in which the flippers move primarily in a vertical plane while continuously being rotated on their longitudinal axes so as to generate thrust in a manner roughly analogous to that of penguins or sea turtles; and a sea lion stroke in which the flippers move downward (and backward (belly-ward)) to produce thrust. Within these hypotheses various proposals have been made for synchronicity of the fore and rear flippers, as well as front flippers propelled while the back flippers were passively employed for stabilization/steering. These models for flipper motion have not been adequately constrained by limits of joint articulation of fossil specimens. Furthermore, the proposed models for plesiosaur propulsion have not previously been experimentally tested; given the inherent complexities of underwater propulsion it is important that conclusions regarding plesiosaur swimming should be confirmed by successful physical demonstrations.

We have reconstructed plesiosaur swimming by firstly taking into account constraints on plesiosaur shoulder and hip joint articulation, and secondly by testing (within the available range of motion) a variety of strokes with human swimmers equipped with facsimile plesiosaur fins, including paired swimming to replicate the action of four flippers at once. Significant results include: plesiosaur limbs are constrained to mostly vertical motion with relatively less fore and aft freedom; in *Plesiosaurus* fore flippers could move through a 55 deg arc and hind flippers only 35 deg below horizontal; and back flippers did assist propulsion. Synchronous or near synchronous movement of the front and back flippers has been found to work best. Propulsion is very sensitive to details of flipper rotation during each stroke as well as small motions at the flipper tips.