Geometric Analysis of Stingray Feeding Behaviour

by **Daniel R. Huber, Leslie B. Jones** and **Rebecca J. Waggett**

We offer here a ready-to-use lesson in geometry which, along with several others, was developed and used for teacher-training workshops conducted at The University of Tampa. Leslie Jones is a mathematician, whilst Daniel Huber and Rebecca Waggett are marine biologists. The lessons were developed with the goal of enticing the learner through context and real-world application of geometric principles. Visit them at our website:

http://utweb.ut.edu/rwaggett/science-math-master.html

The integrated biology–geometry lessons can be found under the 'Model Lessons' tab, in the 'Geometry' column. We have additional resources for this lesson posted on the webpage. The title of this lesson on the webpage is 'Jaw Protrusion.'

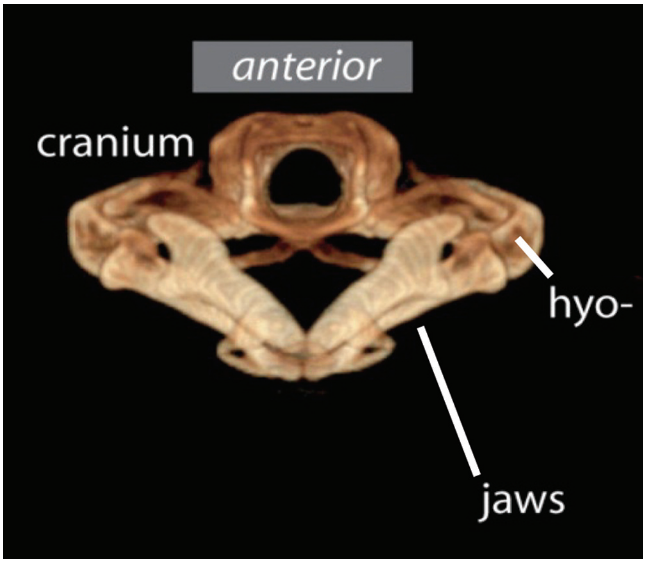
Geometric Analysis of Stingray Feeding Behaviour

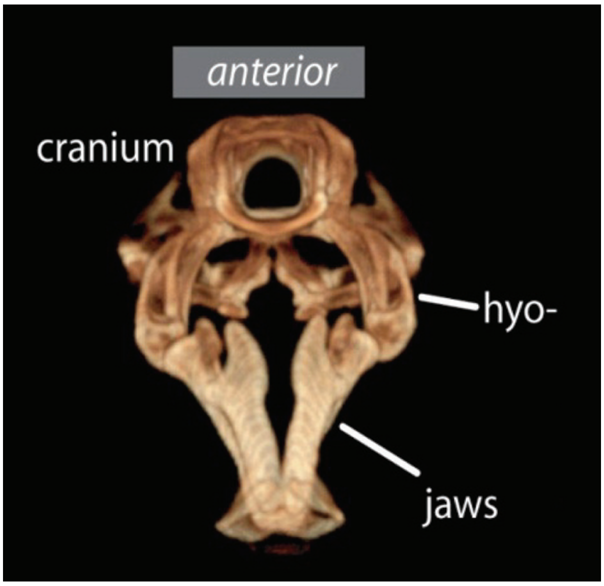
In the wild, fractions of a second often determine whether or not an animal captures its food. Many fish have evolved a unique strategy that enables them to close the distance between predator and prey very rapidly by literally throwing their face at their food! Jaw protrusion (a.k.a. throwing your face at your food) is a behaviour in which the upper jaw, and in some cases lower jaw as well, slide forward beneath the skull very rapidly. This allows predators that chase down their prey to lunge forward at the last instant and predators that ambush their prey to shoot their jaws forward while maintaining a relatively steady body position. The slingjaw wrasse, for example, can stealthily extend its jaws to more than the length of its head to capture small fish. Throwing your face at your food is such an effective feeding technique that some terrestrial vertebrates such as frogs, salamanders, and chameleons, which cannot protrude their jaws because the upper jaw is fused to the skull, launch their sticky tongues out of their mouths to capture unsuspecting prey. Among fish, there are a variety of mechanisms for protruding the jaws. Some stingrays protrude their jaws to feed in a manner analogous to a scissor jack being used to lift a heavy object. This scissor-jack motion allows them to launch a surprise attack on their favourite meals hiding in or near the sand at the bottom of the ocean. We wish to model this behaviour to determine the distance of jaw protrusion during feeding, which will tell us how far above the sea floor a stingray can swim and still effectively reach its food.

This lesson involves finding the angle sizes of isosceles trapezia, determining if quadrilaterals and triangles are similar, and using trigonometric ratios to find side lengths of triangles.

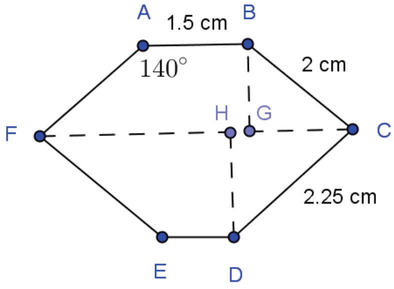
Below is a picture of the feeding mechanism of a lesser electric ray, *Narcine brasiliensis*, in a resting state (top) and in a protruded state (bottom). (Pictures by M. Dean, 2012)

The models on the next page represent the feeding mechanism of a stingray in these two states.

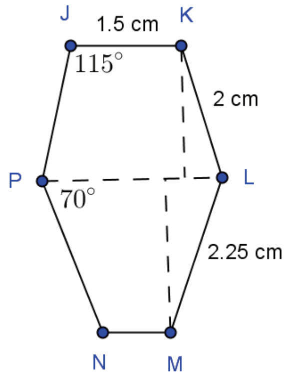




Jaws in Resting State



Jaws in Protruded State



1. ABCF and DEFC are isosceles trapezia. FC bisects angle AFE and angle BCD. Find the size of each angle not already given.
2. Are quadrilaterals ABCF and DEFC similar? Explain.
3. Are ΔCGB and ΔCHD similar? Explain.
4. Find the length of the stingray feeding mechanism from front to back with the jaws in the resting state.
5. JKLP and NMLP are isosceles trapezia. Find the size of each angle not already given.
6. Find the length of the stingray feeding mechanism from front to back with the jaws in the protruded state.
7. From how far above the sea floor can the stingray reach its food?

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