Swimming with the Dolphins

Scientists have been studying the motion of marine swimmers including fish and dolphins for many years. They examine how basic concepts such as the conservation of momentum impact the way an animal moves. In one particular study conducted by a group of four scientists all over the United States, scientists laid an air hose with a bunch of holes in a straight line along the bottom of a dolphin aquarium. Air was pumped into this hose, which escaped through the holes, creating a rising curtain of bubbles. The dolphins were trained to swim in a straight line along the hose. Scientists filmed the dolphin swimming with a high-speed camera and captured the movement of the bubbles. A diagram of this can be found in **Figure 1**.

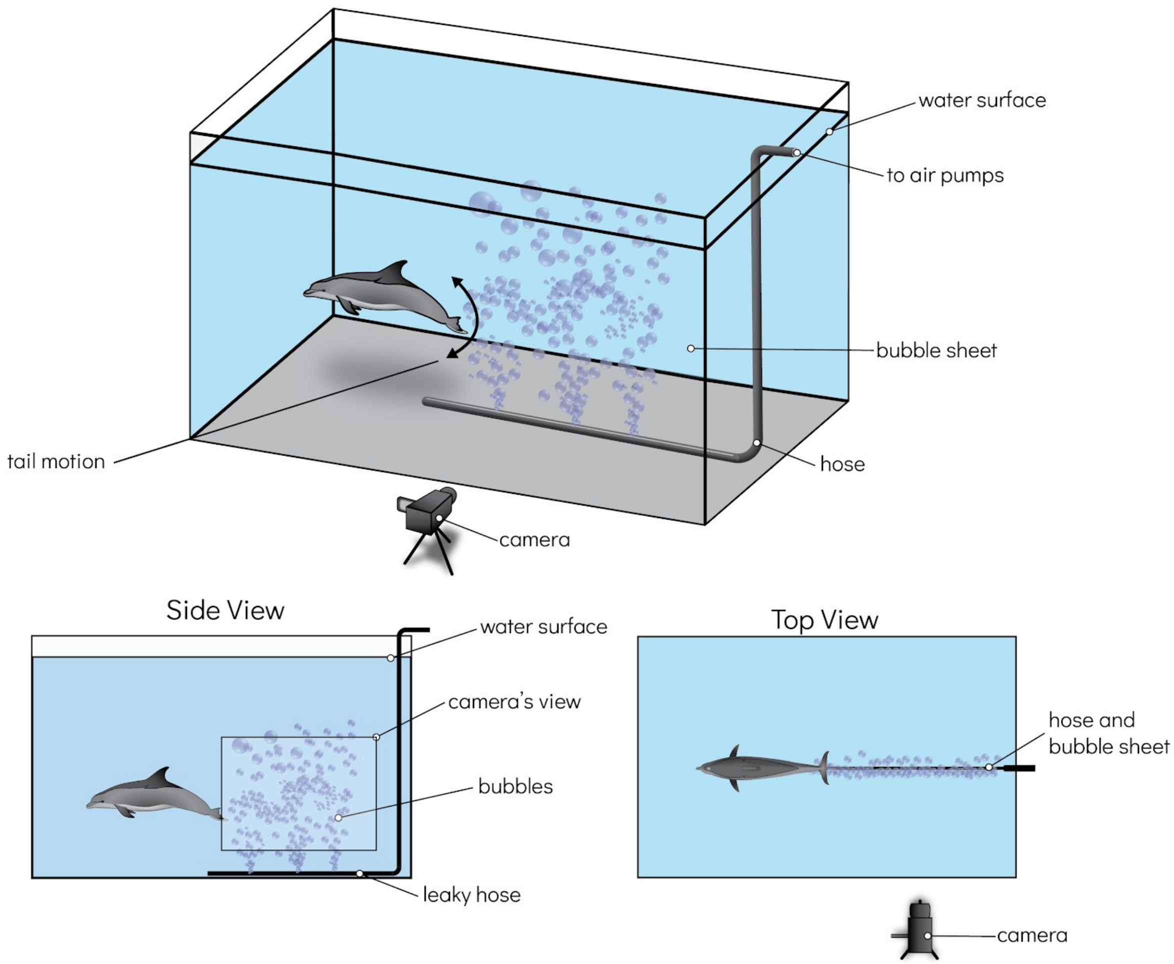

Figure 1. Diagram of Dolphin Swimming Experiment. A curtain of bubbles rising out of a hose on the bottom of the pool let researchers observe how water moves while the dolphin swims.

The scientists were able to find the velocity of the water at numerous points around the dolphin's tail by comparing one picture of the dolphin swimming to the next picture and tracking a bubble in between the two pictures. Knowing the time difference between the pictures and how far the bubble had gone, they were able to determine the velocity of the bubble. After they subtracted out the velocity of the bubbles rising naturally, they had the velocity of the water around the dolphin. From these measurements, they were able to create two dimensional images of how the water flowed around the dolphin as it swam. They then used this to be able to describe the mathematics of how water flows around a dolphin tail while the dolphin is swimming.

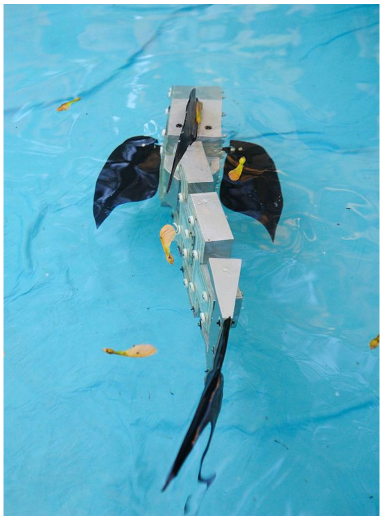

Figure 2. Robotic Fish Swimming. Designing robotic fish depends on understanding the physics behind how real marine animals move. *Source:* Wikimedia Commons.

The scientists were particularly interested in the **vortices**, small pockets of swirling water, like a mini-whirlpool, that were created around the dolphin's tail as it swam. They examined the momentum of the water in order to study the strength of these vortices, and make some estimates of how much force the dolphin's tail produces while swimming. By understanding how much force the tail must withstand, and how a dolphin's tail moves and bends in real life, scientists and engineers can choose the best materials to make **prosthetic** replacement tails for injured dolphins. By choosing materials with the right properties and making those materials move just like the real thing, the replacement tails allow injured dolphins to swim naturally again!

More broadly, by developing a better understanding of the physics behind dolphin movement, scientists can develop new ways for technology to move underwater. Current underwater robotic vehicles are big and bulky and use a lot of energy to move through the water, so they can't be out long before they need to have their batteries recharged. They also can't fit in small spaces or turn and weave their way through underwater clutter like fallen tree branches or a shipwreck. A dolphin or a fish, however, can easily swim around clutter without using so much energy! So, scientists and engineers study how they swim and use this knowledge to inspire new vehicle designs—robotic animals! Since dolphins are really big, current robot designs focus on fish. Even so, because dolphins and fish swim using the same physics, studying dolphin swimming can help scientists build underwater robots like the one shown in **Figure 2**. In the future, scientists hope to use these robots to study the ocean from the shore, which would make research cheaper, easier, and safer. And, these robots also could be used to find and recover equipment lost during shipwrecks and to explore flooded areas for survivors after hurricanes.

Reference

Fish FE, Legac P, Williams TM, and Wei T. 2014. Measurement of hydrodynamic force generation by swimming dolphins using bubble PIV. *Journal of Experimental Biology* 217: 252-260.

BiteScientist Profiles:

Kelsey Lucas is a marine scientist fascinated by how the amazing behaviors animals do arise from the inner workings of their bodies and the physical laws that govern them. By understanding animal behavior holistically, she strives to better understand how the nature works around us and how we can better care for, connect to, and learn from it. In her free time, she likes to volunteer for science education causes like BiteScis or at museums, and to be outdoors running, hiking, and sketching.

Kristen L. Cacciatore is a full-time chemistry and physics teacher at East Boston High School (EBHS), an urban public school serving a high-need student population. Cacciatore, who has a doctorate in green chemistry, leads a high school-elementary school science mentoring program and the Advanced Placement science enrichment and support program for the Boston Public Schools. She also serves as a mentor for beginning and pre-service teachers.