CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Marcus B. Hall

Project Number

J0310

Project Title

Buoyancy Homeostasis: How a Flexible Swim Bladder Naturally Stabilizes Submarine Buoyancy

Abstract

Objectives/Goals

A dynamic buoyancy device should expand/compress to counteract the lost/added buoyancy in the water from heat or salinity. I built a sub with a swim bladder that works like a modern fish and wanted to test if it is better than a modern day submarine that uses a hard tank and better than ancient (400 million years) sharks and Coelacanth that use livers.

Methods/Materials

I tested dynamic buoyancy devices made from stiff materials (ping-pong ball) and from soft materials (air-filled balloon) and static devices made from stiff materials (glass tank), and soft materials (water-filled balloon). Each time, buoyancy devices were the same volume (33ml) and made neutral with weight at the same starting temperature. The water was heated or cooled to see when the device changed buoyancy with a thermometer. Salt or fresh water was added to see when it changed buoyancy with a density hydrometer.

Results

The static systems did not counteract the added/lost buoyancy from the change of temperature and salinity in the water. For example, the glass tank just sinks when the water is heated. However, the dynamic systems counteracted the added/lost buoyancy and gave the device more stability. The dynamic bladder that was made from the stiff material (ping-pong ball) handled the temperature change better than the soft material (air-filled balloon) because the stiffer material only expanded slightly, but the softer material over expanded which made it float quickly. However, the soft bladder was very good at counteracting the change in salinity and the weight of the salt compressed it and lowered the displacement. But the stiff bladder was not able to compress and reduce displacement and it quickly floats. The dynamic bladder fails with warm and salty conditions combined. The stiff bladder counteracts the temperature but the salt does not compress it, and the soft bladder counteracts the salt but expands from heat.

Conclusions/Discussion

My UROV and fish can control buoyancy in fresh, salty, cold, and warm water by changing the stiffness of the swim bladder, unlike the static hard tank used in modern day submarines. But the bladder can fail if the water changes to both warm and salty. This can explain why ancient fish do not have swim bladders. The ancient oceans were twice as salty and warmer than the modern oceans, and it is only in the colder and less salty modern oceans that fish evolved to use swim bladders.

Summary Statement

The swim bladders in fish, unlike the hard tanks in subs, make better buoyancy controls because they naturally counterbalance the effects of changing temperature and salinity.

Help Received

I designed and built an Underwater Remotely Operated Vehicle (UROV) by myself and tested the buoyancy devices in my mom's kitchen. I had a lot of good conversations with Mr. Norman Negus, Mrs. Linda Patterson.