TRAINING&SAFETY

Secrets of Better Buoyancy

by Greg Barlow

Professor Scuba demystifies the science behind sinking and floating.

Buoyancy is a concept all divers are familiar with. After all, we strive for neutral buoyancy at depth, positive buoyancy at the surface and negative buoyancy when it's time to start the dive. With all the attention divers pay to controlling buoyancy, you might think the scientific principles behind it would be as clear to us as a Florida spring. Unfortunately, for many divers, buoyancy basics are as murky as the Mississippi.

A Rather Dense Explanation

So what causes an object to be neutrally buoyant, negatively buoyant or positively buoyant? The Greek mathematician Archimedes pondered buoyancy for quite some time before formulating what is known today as Archimedes' Principle: An object immersed in a fluid is buoyed up by a force equal to the weight of the fluid displaced. This statement sums up the nature of buoyancy in a concise fashion, but it needs some explanation.

A key factor in buoyancy is the property of density--how heavy an object is for its size. A block of lead has greater density than an identically sized block of wood because the lead particles are packed together more tightly than the wood particles. Another way to conceptualize density is to consider a wadded up piece of paper. If the paper wad is loosely compacted, it takes up more space than if it were crushed into a smaller size, but the paper still contains the same number of particles and the weight remains stable.

To Float or Not To Float

Now, the buoyancy part. The density of an object is expressed by its specific gravity. Pure water has an assigned specific gravity of 1.0 to serve as a handy measuring unit. If an object's specific gravity is greater than 1.0, then the object will be negatively buoyant and will sink. The greater the density, the more an object will sink. An object with a density of 5.0 will be very negatively buoyant, but a substance with a density of 1.1 will just barely drop below the surface.

Conversely, if an object's specific gravity is less than 1.0, it will float. The lower the density, the higher the object will rise above the liquid's surface. Think of two pieces of wood floating in water--a light wood like pine floats higher up than a comparatively denser piece of oak.

Not All Water Is Equal

Specific gravity is based on a comparison to pure water. For the most part, seawater has an average specific gravity of 1.03; that's why fresh water floats on top of salt water.

Looked at another way, salt water weighs more than fresh water. A cubic foot of seawater weighs about 64 pounds, while a cubic foot of fresh water weighs approximately 62.4 pounds.

If a given object weighs 70 pounds for each cubic foot, then it will be negatively buoyant in both fresh and salt water, but slightly less so in salt water. However, if an object weighs less than 60 pounds per cubic foot, it will float in both fresh and salt water, but the object in salt water will be buoyed up with a slightly greater force due to the greater weight of salt water. The difference explains why you must add a small amount of additional weight when switching to the ocean from a freshwater lake (see "Fresh-to-Salt Weight Conversion").

Submarines vs. Your BC

So there you have it: An object floats or sinks because of how heavy it is for its volume in comparison to the same volume of the water it's in. With this bit of information then, it becomes clearer as to how we can control buoyancy.

Take your BC, for example. As air is removed from the bladder, the surrounding water pressure forces the material into a smaller, more compact shape. The bladder still weighs the same, but it takes up less space--its density has increased. When the bladder is filled with air, the external dimensions increase, which gives it an overall weight that is less for its size than the surrounding water.

Now imagine a submarine. Instead of a collapsing bladder, the sub's ballast tanks are rigid. The submarine controls its buoyancy by adding or removing water from solid tanks. If the tanks are filled, the sub weighs more than the surrounding water and it sinks. When compressed air is used to purge the ballast tanks, the sub has a lower weight than the same volume of water, and it rises.

Buoyancy Brain Busters

So, is the concept of buoyancy still floating around in your head? Try this little activity to test your understanding. A watertight metal box has a total volume of 2 cubic feet. It also has a given weight of 140 pounds. If this box were placed in seawater, would it be positively, negatively or neutrally buoyant?

Well, if the box has a volume of 2 cubic feet, then an identical amount of seawater would weigh a total of 128 pounds (64 pounds per cubic foot multiplied by 2). Since the given weight of the box is 140 pounds, it is 12 pounds heavier than the surrounding water and will sink.

Fresh-to-Salt Weight Conversion

Remember that an object in salt water is buoyed up with a greater force due to salt water's greater weight. To convert your weight requirements from fresh water to salt water, determine the total weight of your body and equipment. Multiply that figure by .025 and round the answer up to the nearest whole number. This is the additional weight you'll need to add to dive in salt water. Of course, converting from salt water to fresh water would be a matter of removing the same amount of weight.