To Stop or Not To Stop…? And Why

This is when it happens. You're coming up from a great dive, approaching safety-stop depth, when internal conflict begins. What you really want is to be back on the boat as quickly as you can (as in right now, if not sooner). Maybe it's the cold water, too much coffee before the dive, or maybe those refried beans for breakfast. The boat's head, grungy though it may be, looks increasingly attractive. A prolonged safety stop will likely result in a grossed-up wetsuit to clean. The easiest thing for you is to not do the stop, just this once. But there's a reason for safety stops – isn't there? Should you take a chance and skip the stop? How lucky do you feel? How lucky do you need to be to skip it without problems?

(This brings to mind an iconic movie scene where Harry Callahan, pointing a gun, which may or may not be empty, says "You have to ask yourself ‘Do I feel lucky?' Well, do ya, punk?" In the movie scene, the "punk" has enough information to consider his odds and make a decision.)

Back to real life. Do you have enough information to make a sound decision on the safety stop? What would you need to know? At the very least, you would want some estimate of your risk of decompression sickness (DCS, or "the bends") if you completed your safety stop, and some estimate of your risk if you went straight up instead. Only then could you compare them and make a reasoned choice.

Right away, we're running into problems. Dive computers in use today don't operate on principles of reasoned choices or levels of acceptable risk. They operate on a straight "yes/no" basis. (as in "Yes, you may continue this dive at the present depth; no, you may not continue this dive at the present depth.) It’s true that many current dive computers do allow you to initially select your preferred level of risk, but what you are choosing is a relative degree of risk (i.e., more risky or less risky). Nowhere is it specified what level of actual risk any of these different settings represent. Personally, I find such generic categories unhelpful. Compared to some people I know, I'm a major risk-taker; compared to others, I’m not only a stick-in-the-mud, I’ve sprouted roots.

Back in the eighties, a serious attempt was made by Dr. Paul Weathersby, a U.S. Navy scientist, to develop a probabilistic model for predicting the likelihood of decompression sickness. It recognized the obvious fact that, like most natural processes, decompression stress increases progressively, so that no single point exists below which everyone is 100% safe, while above it everyone will get bent. In 1993, the U.S. Navy solicited members of DEMA (The Dive Equipment Manufacturers Association) for a cooperative program that would get this probabilistic algorithm incorporated into an established dive computer. There was apparently some interest expressed, a lot of objections, and, in the end, no equipment manufacturer was willing to sign on. Some of the objections had to do with then-current microprocessors being unable to handle the computations required. (Another interesting objection will be dealt with below.) Now, almost 20 years and several generations of microprocessors later, there are still no probabilistic models in current dive computers.

So we've run into a small roadblock in our decision process. Maybe it will help if we re-start by looking at safety stops themselves.

What effect do safety stops have on diving safety? First, a little background. Unlike the dive tables, or the algorithms that lie at the root of dive computers, the safety stop is basically an "add-on". When dives were a little close to the limits for no decompression diving, it made intuitive sense to do something that resembled a decompression stop, just as a precaution. The feeling developed that this was probably helpful, although, initially, there was no scientific evidence and no real theory that supported this.

The earliest evidence in support was provided by a small, Doppler-monitored study by Dr. Andrew Pilmanis. This demonstrated significant decreases in detectable venous bubbles with safety stops, which might indicate that such stops are useful. Unfortunately, while bubbles detected by Doppler-monitoring do seem to have some correlation with decompression sickness, it's not a very strong relationship. So we're still left with a common sense idea about safety stops, anecdotal evidence (observations by the dive community that stops are helpful), and a limited amount of scientific support.

Where do safety stops fit into theory? Or, more practically, into the theory and algorithms that underlie current dive computers? All dive computers in use today, although different from one another in various ways, are structurally based on the Haldane model of decompression. The Haldane model would predict only minimal benefit to safety stops. So, what’s going on here? Are safety stops just some sort of uninformed superstition, like knocking on wood, or not letting a black cat cross your path? Or do we need to look deeper for answers?

Now would be a good time to revisit the meeting between the U.S. Navy and DEMA, and a very interesting objection made by the equipment manufacturers to the proposed probabilistic algorithm for dive computers. The manufacturers were not willing to make and sell a dive computer that would tell divers their risk of getting "bent" was in the (somewhat unsettling) neighbourhood of 2.5%. And who can blame them for that? For one thing, it could scare off potential divers and, for another, it doesn’t seem to correspond to what divers actually experience. With a DCS risk of 2.5%, a diver with, for example, even 200 logged dives would likely have been bent 5 times. As for dive guides with thousands of dives, they would be almost as familiar with the inside of a recompression chamber as with their favourite bar.

Refusing the Navy's algorithm would seem almost a "no-brainer" for the manufacturers. Except for a couple of inconvenient details. One is that the Navy figures were based on solid experimental evidence. The other is that the manufacturers in fact use the same Navy dive tables (or similar PADI tables) in calibrating the Haldanean models that underlie their own algorithms. If the equipment manufacturers were to turn their own algorithms into probabilistic ones, their estimates of DCS risk would be roughly the same as those in the U.S. Navy's proposed algorithm. It's not that they disagreed with the estimated risk; they just didn't want to declare it.

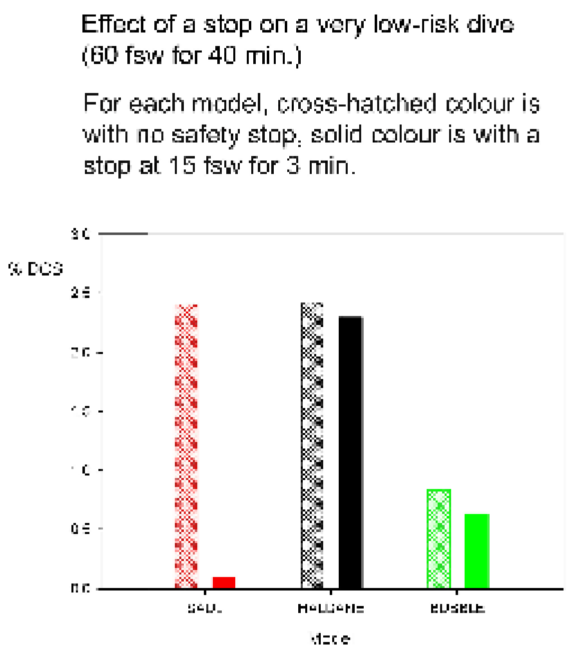
But we're still left with two very different risk estimates. On one side is the experimental evidence of a 2.5% DCS risk. On the other side is the real-life experience of the diving community, where the probability of getting bent amounts to a very tiny fraction of the experimental DCS risk. Clearly, they can't both be right. Or can they?

There is one key difference between the studies conducted by the U.S. Navy and what happens in the day-to-day diving world. Divers in the study were brought to the surface with no safety stops. In normal diving circumstances, safety stops are always recommended, even insisted on. Of course, this can only amount to a difference if safety stops are in fact being used. Recent data provided by Project Dive Exploration (PDE) supports our general observation that the vast majority of recreational diving really does include some version of a safety stop. Specifically, out of 102,642 dives on air, we found that 95.7% of ascents from 20 fsw involved a safety stop – which is pretty good. But when we widened our search a little by looking at all ascents from 30 fsw, we found that fully 99.3% of ascents involved some form of safety stop. In effect, what we found was that, while considerable liberty may be taken with recommended parameters for a safety stop, the overwhelming majority of recreational dives include some sort of safety stop. So, we do have an actual difference between the U.S. Navy studies and the everyday diving world: direct ascents vs. safety stops.

Can safety stops account for the apparent discrepancy between the U.S. Navy results and divers' experience?

Not according to decompression models based on the Haldanean structure – which means not according to the algorithm in your current dive computer. (If it requires you to do a safety stop, as most now do, it's because experience has shown its effectiveness, not because of anything the model would predict.) For the first time, there is a new, patented model of decompression, one not based on Haldanean structure, which predicts the risk of DCS in a more accurate way. This model is SAUL – Safe Advanced Underwater aLgorithm. (Okay, so the acronym's not perfect.)

The diagram below shows how each of three different algorithms would predict the risk of DCS for one typical recreational dive without a safety stop and for the same dive with a safety stop. The algorithms used are a typical Haldane model ("Haldane"), a bubble-based model currently in use by the U.S. Navy ("Bubble") and the author's model ("SAUL").



To what extent can we now answer our original question? How lucky do you need to be to skip your safety stop? It depends on the specifics of the dive and on whose model you believe. Lets suppose your dive was the one in the diagram – 60 feet for 40 minutes.

According to "Haldane", you don't need to be particularly lucky to skip your stop. (Although you might need luck just to continue to dive on a regular basis.) Your risk of DCS would be 2.3% with a stop and 2.5% without one – not a huge difference.

According to "Bubble", your risk of DCS would be 0.7% with a stop and 0.9% without one. Again, not a huge difference.

With "SAUL", skipping your stop would increase your risk from about 0.1% to 2.5%. Or, to put it another way, your dive without a stop is 25 times as risky as that same dive with the stop.

So, what should you do? If you accept the Haldane or the Bubble model as being accurate, it wouldn't make a whole lot of difference if you skip your safety stop this one time – or, in fact, any time you felt inconvenienced by it. But, if that idea makes you as uncomfortable as it does me, you might want to accept that SAUL has the right idea. You would be increasing your risk enormously. You might still get away with skipping your safety stop just this once. On the other hand, you've been in similar situations before, and likely will again. If you skip your safety stop each time, count on getting bent. If you don't plan to skip your stop every time it happens, why skip it even once?

What else should you do? If you accept SAUL as being more accurate in the matter of safety stops, you might want to take a closer look at the model and learn more about it by reading some of the articles below or by visiting one of the author's websites.

While there is no SAUL-based dive computer on the market at present, we're collaborating with Liquivision to get SAUL into a dive computer. No release date has been projected as yet.

Web Links
www.chemistry.uoguelph.ca/goldman
moderndecompression.com