

The Deep: The Physiology of Decompression Sickness

by

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Part I – Treasure Hunt

Dan was an accomplished diver. At 38, he had spent the last decade recreational diving on coral reefs off the coast of Queensland, Australia, with friends. Five years ago he was offered a position as an advertising executive in the United States and so he and his wife Beth moved to the Outer Banks of North Carolina. Beth was a nurse and could easily obtain a position anywhere without too much trouble. The couple had no children, so the move overseas was a good one for both of them.

Dan and Beth spent their weekends by the waterside. Dan continued to dive for fun and Beth was an avid swimmer. Dan made friends with some of the other divers and soon they began diving recreationally at the many shipwrecks located off the coast. Beth also took up diving. She obtained her diving certification after taking a course and an open water test.

In the last two years, Dan had become increasingly more disillusioned with the advertising industry and the long hours he spent at work. He wanted a position where he could be his own boss. His wife also grew tired of working the night shift as she rarely saw Dan during the week. They both needed a change. Following months of discussion, they decided to set up a charter business that involved taking clients out on shipwrecks. Dan was licensed as a dive master. They purchased a used 40-foot fishing boat, named it *Diving Adventures* (after their business name), invested money in new diving equipment, and began advertising online and handing out fliers at tourist information centers. At first business was slow, but by the spring of their second year it began to pick up to the point where by late May they were taking clients out four times a week.

It was June 10th and Dan and Beth left the dock with six clients: two couples—Bill and Jennifer from Connecticut and Nathaniel and Susan from New York—and girlfriends Rachel and Simone from New Orleans. Each was a certified diver but had logged minimal time in the ocean. The day's activity included anchoring 10 miles off the coastline to explore the wreck of the *SS Atlas*, a freighter that was sunk by a torpedo in 1942 from a German U-boat. Dan and Beth had visited the wreck many times as it was rumored to have a lost treasure on-board. When told this story, Bill began to tell tales of what he would do with the money if he found the treasure. Jennifer, however, shrugged off the idea, telling the others that Bill was a dreamer and always one step away from the next get-rich-quick scheme.

They arrived at the dive site, anchored the boat in about 24 meters (80 feet) of water, and began preparing their clients for the day's activity. Beth briefed the divers on the layout of the wreck and correct procedures for the dive while Bill checked everyone's equipment. Everyone was eager to get in the water, especially Bill, but Beth was careful to go over all of the correct procedures involved in the dive including the safety procedures, hand signals, estimated dive duration, decompression procedures, and so forth. Beth informed the group of the 80-foot water depth and that the maximum no decompression limit was 40 minutes, with 5 minutes to descend down the anchor line to the wreck and 35 minutes on the wreck before returning to the surface. After the introduction, all divers were suited up and ready to

go. Beth stayed aboard the boat to monitor events above the waterline and Dan went into the water to lead the way to the wreck.

It was now 11:00 a.m.

Question

1. How do PO_2 and PN_2 change with increasing depth? What are the consequences for human divers as a result of these changes?

Part II – The Dive

Dan slowly led the team down the anchor line to the edge of the wreck. Each diver followed the other, forming a long line on the way down. The amount of light decreased the deeper they went, but there was enough light to see as the water was crystal clear. The water was teeming with fish.

All of a sudden, Dan stopped and motioned to the other divers to do the same. Out of the darkness came what looked like a huge fish. It was a whale. No one on the team could believe what he or she was seeing. It came within 100 feet of them and then slowly swam away. The divers looked at one another in amazement, and then slowly continued to the bottom. Simone, who was a marine biologist, was particularly thrilled. She couldn't wait until she got back to work to tell her colleagues.



Once at the site, Dan tied a flag on the anchor line to indicate the “drop-off area.” Using hand signals, he indicated the perimeter of the vessel, and after checking everyone's dive computer, he indicated the time that each diver needed to be back to the drop-off area before ascending back to the boat.

For the first 5 minutes all of the divers stayed close together, but once their confidence grew, the two couples teamed up and Rachel and Simone began exploring close to the wreck site. Jennifer and Susan tended to stay away from the wreck, but Nathaniel became separated from his buddy and began swimming through the wreck and lifting rocks and debris to see if he could find any artifacts.

Time goes by quickly when exploring a wreck underwater and it wasn't long before the mandatory 35 minutes were up. Initially, after 30 minutes, Jen, Rachel, Susan, and Simone met Dan at the drop-off site. After another 5 minutes, Nathaniel joined them, but there was still no sign of Bill. Dan motioned to Nathaniel to ask where Bill was. Nathaniel motioned back that Bill had wandered off deep into the main wreck site before Nathaniel lost sight of him. At this point, Dan became concerned because he knew how much air each of his party had in their tanks and the amount of decompression time needed to safely leave the bottom. He indicated to the group to begin their slow ascent and he would go searching for Bill.

It was now 11:40 am.

Dan searched for 20 minutes in vain trying to find Bill. On making his way back to the drop-off area, he noticed a loose flipper attached to part of the ship. He began to panic. He swam toward the flipper and noticed Bill with only one flipper trying to pry himself out from two pieces of metal. His foot was wedged between them. Dan tried but was unable to free Bill. Finally he found an iron rod and used it as a fulcrum. This worked and Bill's foot was dislodged. Bill's immediate reaction was to swim to the surface quickly. Dan motioned for him to stop and ascend slowly. On looking at his dive computer and knowing how much time they had to decompress safely, Dan knew that both of them were in trouble. They did not have enough air to reach the surface with a decompression stop. The only thing that Dan could do was to ascend as slowly as possible, making certain they did not run out of air. Dan also noticed that Bill was trying to hold his breath while ascending in an attempt to save air. Dan motioned to Bill to calm down and breathe normally as they ascended.

It was now 12:15 p.m.

The first divers had reached the surface. Beth began counting and noticed that Dan and Bill were missing. She asked Simone where the two men were and Simone explained the situation. Beth helped the divers onto the boat and out of their gear. After 10 minutes, she began to worry. Another 10 minutes went by, and she decided to put on a tank herself

and go down. Just as she was about to enter the water, both divers suddenly surfaced. Relieved, she began to smile when she saw Dan. Her relief was short-lived when she saw that Bill seemed to be disoriented and in some discomfort.

Questions

2. What is decompression sickness and what is the cause?
3. What are some of the common signs of decompression sickness?
4. What is the treatment for decompression sickness?
5. Why don't marine animals, such as dolphins, get decompression sickness?
6. Describe some respiratory and cardiovascular adaptations enabling dolphins to stay underwater for long periods of time.
7. Whales can be deep divers with seemingly no ill effects. In the article by Hooker and Baird (1999), why do they suspect the whale dives were aerobic? Why do whales lower their ascent rate when diving to these great depths?

Part III – The Rescue

When they saw Beth's reaction, the group quickly pulled both divers out of the water and removed their scuba tanks and gear.

Rachel began to cry, "What do we do now?"

Beth replied, "They came up without decompressing. We need to administer pure oxygen and have them lie down. I will radio for help."

Beth made a call for medical assistance on the VHF radio. "This is the vessel *Diving Adventures* hailing the Coast Guard. We are requesting immediate medical assistance."

The radio crackled briefly before Beth heard, "Vessel *Diving Adventures*, this is Coast Guard station Bravo, switch to channel 72, I repeat, channel 72, acknowledge."

Beth replied: "Switching to channel 72." After what seemed like a very long silence the Coast Guard replied, "*Diving Adventures*, what is your emergency?"

Beth said, "We have divers who need immediate attention due to possible decompression sickness. Do you copy?"

The Coast Guard responded, "Roger. We can dispatch a helicopter from Elizabeth City, North Carolina, and have them at your location within 30 minutes. Do you copy?"

Beth replied, "Copy that; please hurry. *Diving Adventures* standing by on channel 16."

Beth returned to the stern of the boat and instructed Dan and Bill to lie still as she covered them with a blanket until help arrived. Bill's symptoms seemed to be getting worse. He began to have more trouble breathing and complained of numbness on one side of his body. In the meantime, Dan, who seemed fine earlier, began complaining about feeling fatigued and his left shoulder also began feeling numb. Beth knew that both were exhibiting symptoms of decompression sickness.

Within 40 minutes they heard the sounds of a helicopter above. The blades were now directly above their heads as a basket was winched down to them. Bill was the first to be lifted up to the helicopter, then Dan.

As the helicopter sped away, Beth started both engines, pulled up the anchor, and headed to the marina.



Question

- Once in the helicopter, the paramedics try to stabilize both patients. Would flying at high altitude worsen their condition? Why?

By this time it was 11 p.m. that night. Beth and Jennifer were in the waiting room when the attending physician told them the good news that the divers' condition was stabilized and that they wanted to keep both men in the hospital overnight for observation.

Part IV – The Recovery

While in the helicopter, paramedics tried to stabilize both patients as best as they could. The numbness in Dan's shoulder continued. The paramedics placed a cold compress around his shoulder and wrapped it tightly. They administered oxygen and instructed him to breathe normally.

Meanwhile, Bill was placed on a portable ventilator to help with his breathing, but he continued to have numbness on one side of his body.

The pilot of the helicopter flew as low as aviation standards permitted while speeding to the nearest hospital that had a hyperbaric chamber in case the divers need to be placed inside one.

On arrival at the hospital, attending physicians saw both patients. A summary of their symptoms is shown in Table 1. Based on these symptoms, the doctors decided to place both patients into a hyperbaric chamber for treatment. Within an hour in the chamber, both patients' symptoms began to subside, and treatment concluded after a total of 8 hours in the chamber.



Table 1

<i>Dan</i>	<i>Bill</i>
Numbness in the shoulder	Numbness down the left side of the body
Complaints of fatigue	Difficulty in breathing

Question

9. What are some of the long-term effects of decompression sickness?



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