DECOMPRESSION RISK EVALUATION FOR TRIMIX DIVES DERIVED FROM COMMERCIALLY AVAILABLE DESKTOP DECOMPRESSION ALGORITHMS

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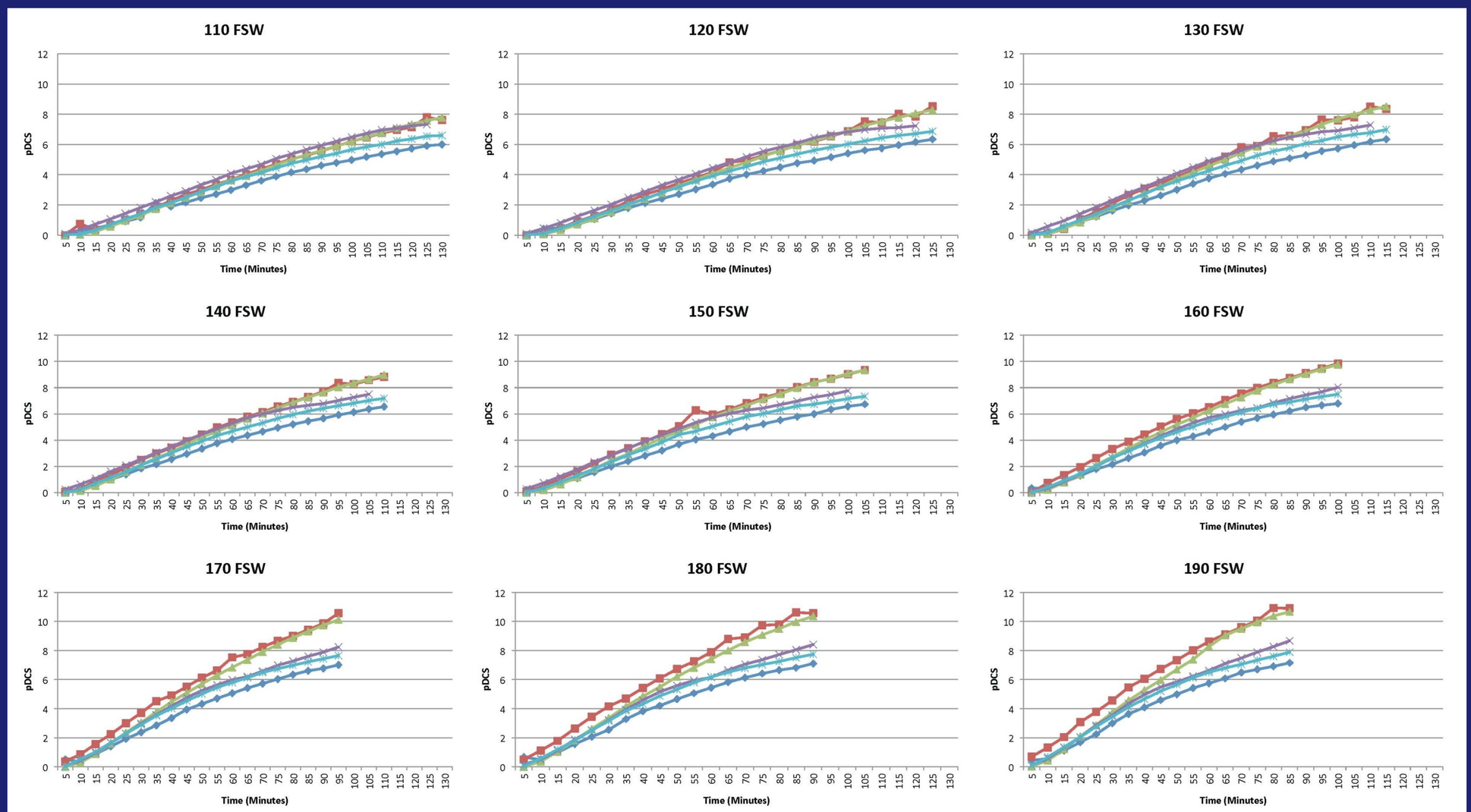
Introduction

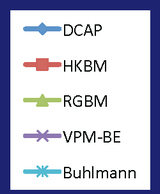
Probabilistic decompression models are used to predict the risk of decompression sickness associated with a given hyperbaric exposure (dive). We evaluated the risks associated with the given set of dive profiles with the US Navy Linear Expoential Multigas (LEM) probabilistic model. These profiles represent typical dives planned and conducted by technical divers.

Method

We produced decompression tables for trimix 21% O2, 35% He, balance (44%) N2 dives with 50% nitrox and 100% oxygen decompression gases. Bottom times were limited to the time one could safely dive using the "rule of thirds" on double E8-130 cylinders with a single aluminum 80 cubic foot stage bottle neglecting gas needed during ascent prior to decompression gas switch. The software and models tested include: DecoPlanner (Global Underwater Explorers, High Springs, FL) Buhlmann, GAP-Software (Heerhugowaard, Netherlands) Reduced Gradient Bubble Model (RGBM), NAUTILUS Dive Planner* (Lake Havasu City, AZ) Decompression Computation and Analysis Program (DCAP) and Hamilton-Kenyon Bubble Model (HKBM), and V-Planner (HHS Software Corp., Kingston ON, Canada) VPM-B/E. Default software settings were used confirming final decompression stop depth of 10fsw.

Risk predictions were made using the Linear Exponential Multi-gas Model (LEM) [1]. This risk model is the NMRI98 model utilized in our previous work on the efficacy of oxygen decompression [2] extended to include three diffusible gases, in this case oxygen, nitrogen, and helium. LEM was fit to the he8n25 data set which includes 4,669 dive trials split between 1,347 profiles. This data set includes 242 cases of decompression sickness and 118 marginal cases of decompression sickness. The bulk of the profiles within this data set are heliox exposures however, some nitrox and trimix exposures are also included.





In the figures above, estimated risk from LEM is plotted for the five commercial software products versus bottom time for various maximum depths. This style of graph was chosen to emphasize that the estimated risk for the no-stop limits are similar for all the software products tested, and risks increase as the bottom time lengthens. The risks of the no stop limits are approximated by the first point in each line of the above figure.

Results

The risk analysis of the selected profiles showed a consistent trend of increased risk with increased time and/or depth. We found that predicted risks ranged from 0% up to 10.89% (190 ft/ 85 min BT). With HKBM and RGBM consistently giving the highest risk schedules and DCAP giving the lowest risk schedules. For exposures less than 20 minutes there was little difference between the algorithms tested. Exposures lasting longer than 20 minutes lead to a much larger spread in risk between the schedules tested.

* Nautilus software called for instant decent, we used 0.01 seconds

Discussion

The profiles are not iso-risk. The maximum risk appears with greatest depth/ bottom time. The lowest risk was not necessarily on the shortest/ shallowest combination.

This risk analysis was performed on square dive profiles with a direct descent to depth, maximum stay at the maximum depth followed by a direct ascent to the first stop depth. These parameters are used to plan adequate decompression for the maximum possible dive within these confines. It should be recognized that for most recreational technical dives, majority of the dive profile will not be spent at the maximum depth. This deviation from a square profile reduces the estimated risk when dived with the planned decompression schedule.

While this work provides a good starting point for differentiating these algorithms there is a lot of room for follow on work. Validating these results with a second model or enhancing LEM's parameter set by fitting to data with more trimix and/or exposures including both heliox and nitrox would be good next steps.

References

1. Gerth WA, Johnson, TM. Development and Validation of 1.3 ATA PO2-in-He Decompression Tables for the MK 16 MOD 1 UBA. Panama City, FL: Navy Experimental Diving Unit, 2002, NEDU TR 02-10. http://archive.rubicon-foundation.org/3548
2. Walker JR, Hobbs GW, Gault KA, Howle LE, Freiberger JJ. Decompression risk analysis comparing oxygen and 50% nitrox decompression stops. Undersea and Hyperbaric Medical Society Annual Scientific Meeting, St Pete Beach, Florida, USA. Undersea and Hyperbar Med 2010; 37(4) http://archive.rubicon-foundation.org/8967

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