

# A HARD LOOK AT DECOMPRESSION SOFTWARE

By **BILL HAMILTON**  
and **GEORGE IRVINE**

Since scuba diving became popular after World War II most divers have relied on the U.S. Navy Standard Air decompression tables. More recently new air tables have come from Canada (the DCIEM tables), and the U.K. (the BSAC tables), and there are some others not so well known; add computers to this and air diving is well covered. For diving with mixtures other than air, all the recreational and sport diving communities had to work with were ad hoc tables created by themselves or "air equivalent" tables such as those created by NOAA and various training organizations for enriched air "nitrox" diving. Commercial diving companies, at least some of them, developed their own tables, but they were based on a different diving scenario, using hoses, bells, and techniques such as surface decompression. Suitable tables for heliox and trimix diving by self-contained recreational divers were simply not available.

The need for special tables by some of the more assertive cave divers and their colleagues such as Parker Turner, Bill Gavin, Bill Stone, and others, led to development of a new style of diving based on custom decompression tables as well as many other innovations, special equipment and techniques. The early programs used tables prepared by Dr. Bill Hamilton using his "DCAP" program. This was for all practical purposes the dawn of "technical diving," and it depended on custom tables.

Almost immediately other enterprising individuals began to input Dr. Buehlmann's decompression algorithm into spread sheets or original programs to generate schedules for

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trimix diving. Buehlmann's algorithms were chosen first because they were available (in published form), but also because in many cases they were suitable for this type of diving. The first to bring a commercial "do-it-yourself" decompression computation program to market was the late Corey Berggren with the DPA, and this was based on Dr. Buehlmann's algorithm.

The real question is, "What really works?" This has been answered in a number of ways to the satisfaction of most divers. In a nutshell, most applications using Buehlmann's implementation of the Haldane concept will yield satisfactory results. Professional table generators like Hamilton Research, as well as some commercial diving companies and military diving operations have formulas, some of them proprietary, tested with hundreds of man hours, but the software which is now available to most divers seems to match these results fairly closely.

However, a couple of caveats apply to those who plan to use decompression

software: (1) you need to understand decompression before you try to use these devices, and (2) they are theoretical (model based) and may not work in all cases, and are not likely to work when carried to extremes. To borrow from Dr. David Elliott in this regard, "Don't worry about what you don't know, worry about what you think you know which may not be right".

### The Review

We review here six currently available programs from the viewpoint of using them as a diver, with comments on the basis of what they do.

The six programs are: Abyss, by Abysmal Diving; DECOM by Bell Computing; DPA by Cybertronics; Dr. X, by Deep, Inc.; MigPlan, by Mig Technologies; and ProPlanner, by Aquatronics. A comparative listing of the programs and key characteristics is given below.

The recommended decompression for a given profile are quite similar for all the programs, all things being equal, i.e., using similar so-called "safety" factors

(better to say "conservatism" since safety is more complex than this). This is not surprising since they all use the same basic computational method or algorithm. Some of these can be adjusted severely, some mildly, some not very much.

All of these programs produce adequate decompression schedules, but our experience suggests that all of them when used in their default or intended fashion produce schedules that are subject to improvement. This is not to say that they do not adequately reflect the theories upon which they are based; they do. The problem is that not any one of these theories even comes close to being an adequate description of the physiological decompression process. This is why it is more correct to talk about a computational algorithm than a model, which has more intricate implications.

One way to get a proper decompression would be a combination of bubble mechanics to pick up the deep stops, and control of off-gassing to manage the shallow stops. A straight Haldanian

| Program    | Version Tested          | Authors                    | Cost     | Platform   | Gasses and Limits                    | Model                        | CNS O2 Tracking | Gas Mixing | Dive Logging | Altitude Diving |
|------------|-------------------------|----------------------------|----------|------------|--------------------------------------|------------------------------|-----------------|------------|--------------|-----------------|
| Abyss      | Recreational v1.2       | Chris Parrett<br>Paul Rony | \$79.99  | Windows    | Air<br>Max 130 ft.                   | Derived<br>Bühlmann 32       | Yes             | No         | Yes          | Yes             |
|            | Nitrox v1.2             | Chris Parrett<br>Paul Rony | \$99.99  | Windows    | EANx 32 & 36<br>Max 180 ft.          | Derived<br>Bühlmann 32       | Yes             | No         | Yes          | Yes             |
|            | Tech Nitrox v1.2        | Chris Parrett<br>Paul Rony | \$199.99 | Windows    | O2/N2 Mixes<br>Max 227 ft.           | Derived<br>Bühlmann 32       | Yes             | No         | Yes          | Yes             |
|            | Mixed Gas v1.2          | Chris Parrett<br>Paul Rony | \$299.99 | Windows    | O2/N2/He Mixes<br>Max 325 ft.        | Derived<br>Bühlmann 32       | Yes             | No         | Yes          | Yes             |
|            | Advanced Mixed Gas v1.2 | Chris Parrett<br>Paul Rony | \$399.99 | Windows    | O2/N2/He/Ne/Ar<br>Mixes, Max 650 ft. | Derived<br>Bühlmann 32       | Yes             | No         | Yes          | Yes             |
| DECOM      | v6.5                    | Abdur Chowdhury            | \$69.99  | DOS        | O2/N2/He Mixes                       | Bühlmann 16                  | Yes             | Yes        | Yes          | Yes             |
| DPA        | v2.1                    | Cory Berggren<br>Jim King  | \$79.99  | DOS        | O2/N2/He Mixes                       | Bühlmann 12 or 16            | Yes             | Yes        | No           | Yes             |
| Dr. X      | v5.03                   | Sheck Exley                | \$250.00 | DOS        | O2/N2/He Mixes                       | Bühlmann 16                  | Yes             | Yes        | No           | Sea Level Only  |
| MIG Plan   | v1.0                    | Dan Nafe<br>Jody Svendsen  | Freeware | DOS or Mac | O2/N2/He Mixes                       | Bühlmann 16<br>or Huggins 12 | Yes             | No         | No           | Sea Level Only  |
| ProPlanner | Air v5.0                | Kevin Gurr                 | \$200.00 | DOS        | Air Only                             | Bühlmann 16                  | Yes             | Yes        | Yes          | Yes             |
|            | TriMix v5.0             | Kevin Gurr                 | \$350.00 | DOS        | O2/N2/He Mixes                       | Bühlmann 16                  | Yes             | Yes        | Yes          | Yes             |
|            | Nitrox Rebreather v5.0  | Kevin Gurr                 | \$450.00 | DOS        | Nitrox<br>Rebreathers                | Bühlmann 16                  | Yes             | Yes        | Yes          | Yes             |



approach to picking up the deep stops, as done for example by MiG Plan, can swell the shallow stops to an unmanageable level, much like all these programs will do if the conservatism factors are bumped up. This can usually be through some form of legerdemain, like changing the conservatism factors while running, or inserting a different gas, or using a greater depth (a common and effective method is to lower the oxygen fraction). In other words, you more or less have to already know the answer before you ask the question.

Abyss has just released a new version of its software, 1.4, which incorporates some constraints based on Bruce Wienke's Reduced Gradient Bubble Model. This only increases the necessary decompression, it will not reduce it. It examines dives fitting the popular concepts of dives believed to be unusually risky, such as closely spaced repetitive dives, yo-yo dives, deep after shallow, and some patterns of multiday diving. It then increases the required decompression to compensate, according to Wienke's bubble model. We have not yet tested this version. It does not calculate dives according to the RGBM model, it just modifies what you have. Abyss also allows the user to program the anticipated work load of the diver and provides some options for introducing conservatism according to a logical but arbitrary plan, and it provides a thermal compensation and other parameters as well. In all, Abyss has over 800 factors that can be adjusted by the user.

### General Comments

All six programs are intuitive and generally are self-explanatory and easy to use, with the more complex, like Abyss, requiring more effort but yielding more information. All have a simple mode, like the "walk through" in Dr. X which asks the user for very little detail of the dive.

All except Abyss and Mig Plan have a gas mixer, which is easy to use in DECOM, and somewhat archaic in ProPlanner and Dr. X (Dr. X expects all mixes to be made with pure helium and air).

### Narcosis

All of the programs provide some method of estimating the narcotic dose of a given gas mix at a given depth. There are a

## Future Updates

**Dr. X**—Sheck Exley built a expiration time limit into Dr. X that renders the program unusable after January 1, 1996. This combined with his unfortunate death last year made the future of his Dr. X software unknown. Ralph Hood, of Underwater Connections, Inc., has recently worked out an agreement with Mary Ellen Eckhoff, Sheck's partner, to continue development and support of Dr. X. Underwater Connections is modifying the program to remove the expiration date feature and will continue sales and support of the product along with the Macintosh version that Sheck was completing just prior to his death. All proceeds from sales of Dr. X will be donated to the Sheck Exley Safety and Education Fund which is being administered by the NSS-CDS.

**Adept**—The only decompression program to be ported to a Personal Digital Assistant (PDA) is a program called Adept, developed

by Andrew Pitkin. Features of Adept include support of any O<sub>2</sub>/N<sub>2</sub>/He mixture, Bühlmann 16 modeling, multilevel and repetitive dives, gas consumption, CNS O<sub>2</sub> tracking and gas mixing. Adept runs on an Apple Newton MessagePad and requires about 200k of memory to run. Pitkin is actively working on a Macintosh version that should be completed sometime in 1996. Questions regarding Adept can be sent to Pitkin at [apitkin@cix.compulink.co.uk](mailto:apitkin@cix.compulink.co.uk).

**Abyss**—Abysmal Diving, Inc. is currently working on a Macintosh version of Abyss that should be shipping by Spring of 1996. The next Windows version (v1.4) will include a Gas Mixer and incorporate Dr. Wienke's RGBM modeling theory.

**DECOM**—Bell Computing will release version 6.6 early in 1996 and is beginning work on a windows version as well. Upgrades are free within 90 days of purchase.

couple of problems with this. First, as a reminder, because of its narcotic properties diving deep with air is highly dangerous when a situation presents itself that might require concentrated thinking. Likewise, when diving with either trimix or enriched air it is foolhardy to push the narcotic limits. Given this, the programs all allow the diver to calculate the level of narcosis of the current mix. However, as far as we can tell all except Abyss do it on the assumption that only the nitrogen is narcotic, and that the equivalent narcosis of a mix can be calculated by considering only the nitrogen partial pressure in the mix. In fact, oxygen is also narcotic gas. Most likely it is even more narcotic than nitrogen. There is little documented data addressing this question, but what little is available says that there is little or no difference in narcotic potency (as measured by performance testing) between air and an N<sub>2</sub>/O<sub>2</sub> mixture at the same total pressure. Thus the way to calculate the equivalent narcotic depth is to consider both the nitrogen and oxygen components and compare the total with air at the same depth. Abyss provides a more sophisticated method of estimating narcosis and even allows the user to consider oxygen to be narcotic (which is probably the right thing to do—this is new ground for us to cover).

Another hazard lurks in the concept of a "personal narcosis depth," such as that calculated by Dr. X and ProPlanner. It is indeed true that people vary somewhat in their susceptibility to narcosis (and to oxygen toxicity as well, perhaps even more). This allows the "macho man" to labor under the mistaken belief that his tolerance is greater than anyone else's, and to plan his mixes accordingly. Suffice it to say that there are some notable examples that this is not a good practice.

### Oxygen Exposures

All of the programs provide help in managing the exposure to oxygen, particularly with regard to avoiding CNS O<sub>2</sub> toxicity which may manifest itself as a convulsion. Some programs beep when the current profile contains a ppO<sub>2</sub> regarded as excessive. The diver's approach to the limit is also monitored. The basis for this is the method used in DCAP, which is essentially an interpolation of the limits for oxygen exposure in the 1991 NOAA Diving Manual. This calculation produces an oxygen limit fraction by accumulating each minute of exposure in fractional increments as a portion of the total limit, such that when the increments add up to a value

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of 1.0 the diver has reached the NOAA limit. This is also commonly referred to as "CNS%," which is the same thing but presented as a percentage instead of a fraction. CNS% refers to the percentage of the allowable exposure that has accumulated. Abyss allows the user to adjust the formula for calculating the approach to the limit. Abyss also allows the user to select a recovery halftime. This is the decay of the limit fraction during the time when the oxygen exposure is normal or nearly normal.

It should be pointed out here that just like a decompression table does not guarantee a diver will not get DCS, staying within the oxygen limit does not guarantee a diver will not get CNS toxicity.

### **Mig Plan and ProPlanner Summary**

ProPlanner and Mig Plan are relatively simple programs without much flexibility and are inappropriate for technical or complex dive plans. However, they will work fine for routine recreational or rectangular applications.

### **DPA and Dr. X Summary**

In the midrange there is DPA and Dr. X. They are good for more complex, multilevel dive plans, and are great to use for learning this kind of diving, as they walk the user through the dive. DPA is less user friendly, but more powerful; it allows the user to go back and dynamically change the dive plan and see the effect on the profile. DPA has some routines in the latest version that emulate the popular trimix method developed with Hamilton's DCAP. Dr. X has a terrific walk-through mode that queries the user for each piece of required informa-

tion throughout the dive. This is an excellent feature for novices.

### **DECOM Summary**

This leaves the real contenders, Decom and Abyss. These programs are intended for the pros, and they merit careful use. Decom has wonderful features, like displaying the changes in the ceiling throughout the input process, and allowing in-gassing and off-gassing to be conducted in any sequence. Conservatism factors can be set at any level, and you can move any direction throughout the decompression. It will allow a batch or "family" of tables to be generated with different matrix times in one location, and this can be done with tables overall. It allows the oxygen limit fraction or CNS% function to be monitored. We have calculated extremely complex multilevel dives with Decom, and have found its recommendations to be compatible with profiles actually used and successfully concluded on some of the biggest cave dives ever done.

### **Abyss Summary**

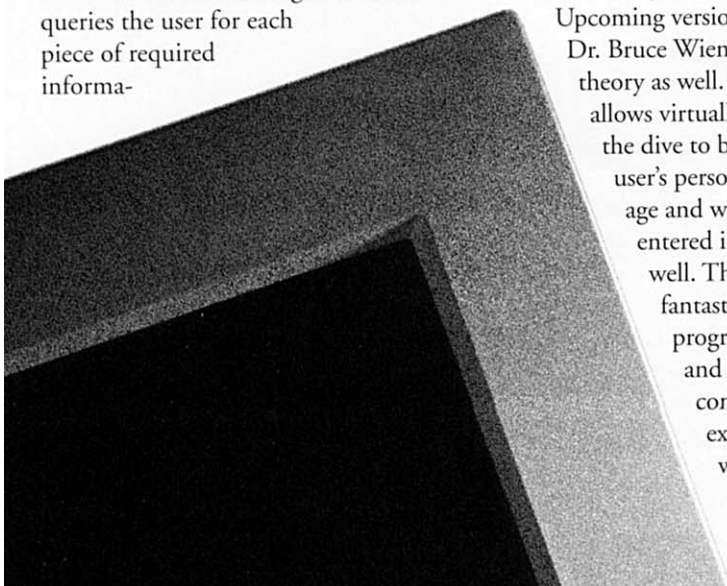
Abyss is a masterpiece. Chris Parrett has really poured his heart and soul into this one. It is Windows based, and fully incorporates the graphical user interface inherent in Windows. Abyss provides the user with access to the building blocks of the decompression algorithm, including such things as factors for each of thirty-two tissue compartments (32 compartments allow for some fine tuning, but for practical purposes this is more than is really needed). It offers three basic variations on the algorithm, using different levels of conservatism achieved by slowing the outgassing. Upcoming versions will incorporate Dr. Bruce Wienke's RGBM bubble theory as well. The program allows virtually every aspect of the dive to be specified, and the user's personal variables like age and weight can be entered in as variables as well. The graphics are fantastic, and the program is well written and well supported. It comes with an extensive manual as well as comprehen-

sive on-line help. It also tracks the oxygen limit fraction and will generate sets of tables entirely or in sections.

### **Real World Analysis by George Irvine**

Most of our extreme dives are conducted according to commercial tables produced by Hamilton Research. I checked sample Abyss and DECOM dive plans against dives in my logbook that produced asymptomatic decompressions which were confirmed by doppler. Both programs produced tables that matched what I had used, so long as I injected three or four short deep stops into the plan prior to using the first stop recommended by each of the programs. Whether or not these deep stops were necessary is supported only by the fact that I did get mild DCS (Type I) when I didn't do the deep stops. However, I only allowed this to happen twice in 200 dives, so this is not exactly conclusive. The point is that both Abyss and DECOM produced tables as good as the custom tables I have used from commercial sources. I also checked some wreck dive profiles that had worked well in the field and found the same conformance. These are a very few data points, but they are better than none.

Some examples follow: Indian Springs is a peculiar dive in that you must travel a mile at 150 feet and then drop to 300 feet for exploration. This we do with trimix carried on our backs and with nitrox and trimix placed in stages in the cave. At Sally Ward Spring, we go in at 100 feet for several minutes, drop to 300 for several minutes, come up to 250 feet for a while, and then begin exportation at 220, reversing this process on the way out. In Leon Sinks, we get multilevel dives which result in bottom times of over 100 minutes with 220 ft. profiles, and have shallow spots interspersed throughout. At Wakulla Springs, we deal with rectangular profiles in the 300 foot range, with bottom times of 75 to 100 minutes, and at Manatee, we deal with up to 300 minute bottom times. Testing all of these complex profiles on DECOM and Abyss resulted in profiles that matched our experience with commercial tables.



### Where to Get Them

**Abys**—Abysmal Diving, Inc., 6595 Odell Place, Suite G, Boulder, CO 80301, USA, 303-530-7248, [chris@abysmal.com](mailto:chris@abysmal.com). Also available at any IANTD Facility.

**DECOM**—Bell Computing, 808 South Highland Street, Arlington, VA 22204, USA, 703-658-8596, [rbell@cpcug.prg](mailto:rbell@cpcug.prg)

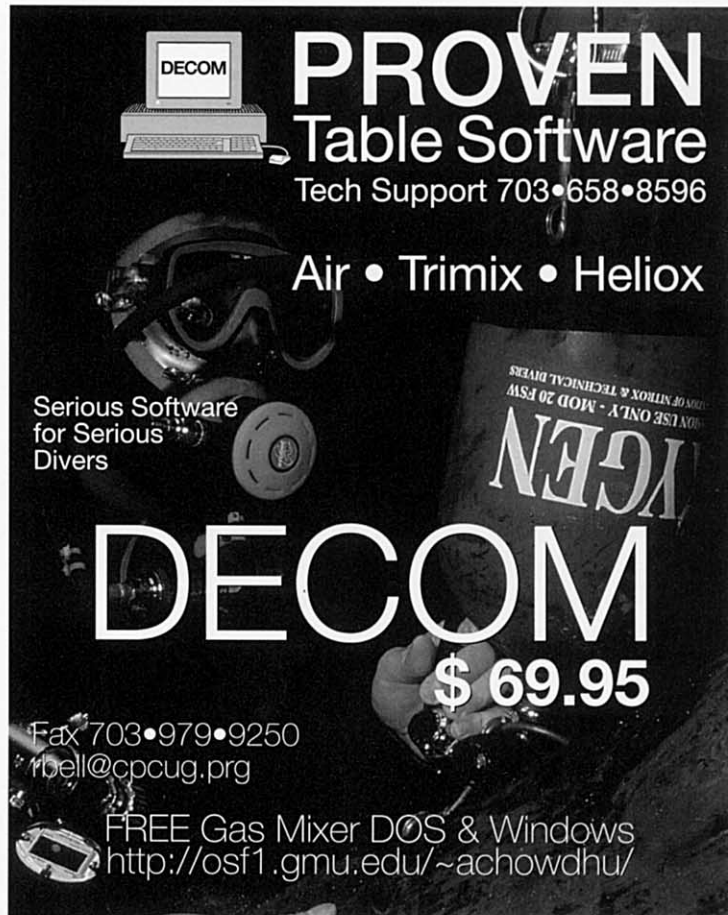
**DPA**—Deep Breathing Systems, Inc., P.O. Box 4220, Severville, TN 37864, USA, 423-453-7177, [72425.1612@compuserve.com](mailto:72425.1612@compuserve.com)

**Dr. X**—Underwater Connections, Inc., 171 Cornell Dr., Newport News, VA 23608, USA, 804-872-8741.

**Mig Plan**—Macintosh version available for download at <http://www.safari.net/mig>. DOS version available for download at <http://shadow.net/mig>.

**ProPlanner**—Available at all IANTD Facilities. For the facility nearest you call 305-751-4873 in the USA, or call 01202 632932 in the UK. 🇺🇸

*Dr. R. W. Bill Hamilton is Founder and President of Hamilton Research. George Irvine is Director of the Woodville Karst Plain Project and a Stock Broker in Ft. Lauderdale, Florida.*



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