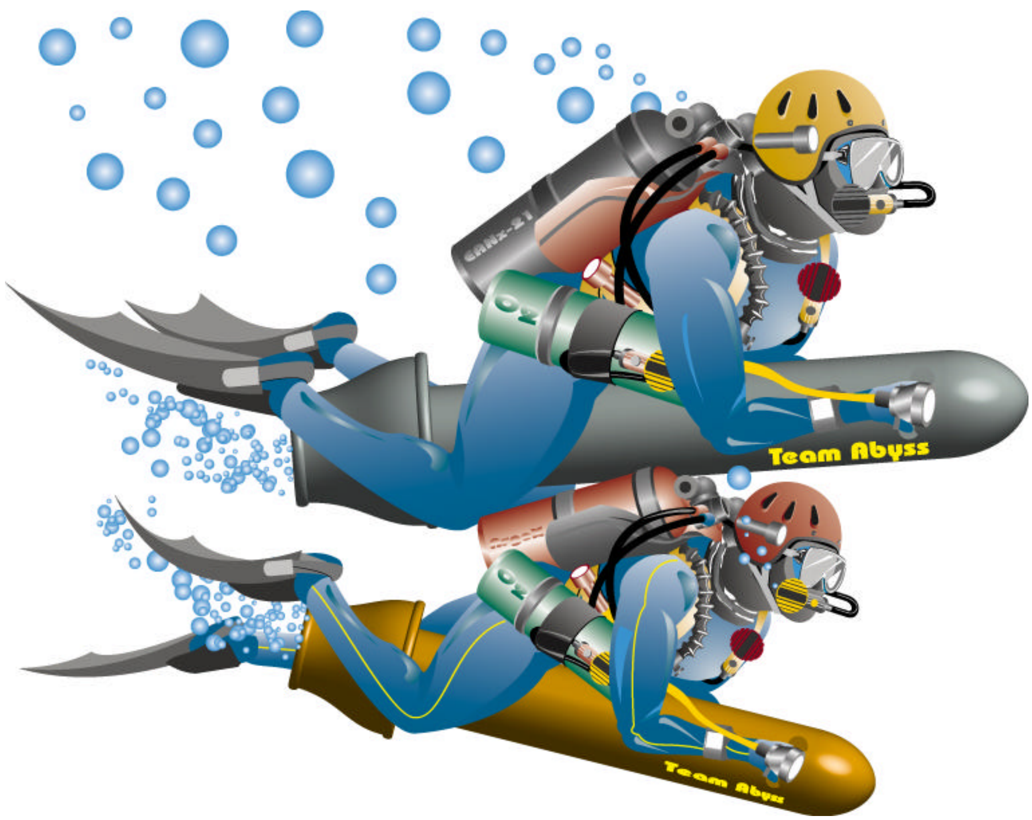
Abyss

Advanced
Dive Planning Software



WARNING!

Users of do-it-yourself programs for performing decompression computations, including ABYSS, should understand that the programs <u>do not immediately solve all decompression problems</u>.

A considerable store of experience comes with ABYSS, but the relevance of available experience may vary considerably between different types of dives.

ABYSS itself cannot provide judgment as to choice of its many variables, but examples and advice are available to users from Abysmal Diving Inc. as part of the ABYSS package.

The program requires a knowledge of diving physiology and operations, and some training and study of the ABYSS system by the potential User in order to operate it effectively.

The fact that a table was generated by ABYSS does not specify how it was computed, <u>nor does it guarantee freedom from the possibility of decompression sickness.</u>

That possibility exists with all diving, and divers should be well aware of it.

Abyss, Advanced Dive Planning Software

The Software product described in this manual is provided under a User Agreement and may only be used in accordance with the terms of that User Agreement.

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Abyss

Advanced **D**ive **P**lanning **S**oftware

For Abyss V2.2x

Manual revision #165
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Introduction to Abysmal Diving Inc.

Abysmal Diving Inc. is a computer software manufacturer with headquarters in Boulder, Colorado (strange place for a diving company you say, well read on..). Abysmal Diving was formed in October of 1993 to develop and market high performance computer software for the mainstream and technical diving marketplace. The founder of Abysmal Diving, Christopher Parrett, has been an active diver since 1979, and is currently a NAUI instructor, NSS-CDS/NACD Cave Diver, a TDI trained technical diver and member of numerous industry & medical groups.

As a certified Emergency Medical Technician (with both civilian and military training and experience), he has a knowledge of the medical and hyperbaric aspects of technical diving and dive planning. Mr. Parrett has over eight years experience in the computer hardware and software industry, and has substantial experience in international sales of computer hardware, software and components. Chris currently holds a bachelor's degree in prelaw from the University of Colorado at Boulder.

The creation of the Abyss, Advanced Dive Planning Software package has been long in the making and came about due to the Chris' personnel frustration in planning high altitude mine dives in the mountains of Colorado. (It seems that what Colorado lacks in warm water reef diving, it makes up for with an abundance of crystal clear flooded Gold Mines from Colorado's Gold Rush era that are just waiting to be explored) It was during the late summer of 1993 that Mr. Parrett saw the need for a full dive planning and interactive data logging Windows-based package that would meet the requirements of both novice and serious technical divers, and became aware that there was no software currently available that would allow the complete modeling & planning of an advanced technical dive. Chris felt that this kind of dive planning needed to account for Water Temp, Altitude, Workload, Ascent and Descent rates, the use of multiple gases and multiple depths among other things. With this in mind, he launched a series of discussions on this topic on the international SCUBA Forum of CompuServe. Due in great part to the tremendous amount of feedback from divers all over the world, the Abyss project was undertaken in September of 1993.

With the assistance of over 40 international beta testers consisting of solely of highly active divers and dive industry leaders in Australia, Canada, France, Germany, Mexico, Sweden, the UK and the USA, the Abyss software code was developed and tested. A Beta-test group was assembled to represent the entire spectrum of dive skills, from recreational SCUBA to advanced technical diving and scientific research. Individuals such as Dr. Bill Hamilton, Dr. Max Hahn and John Crea were sought out for input on hyperbaric physiology. Capt. Billy Deans, Michael Menduno, John Comly, Joel Silverstein and Robert Palmer were used for their specific technical diving expertise. Richard Pyle and Gregg Stanton contributed their scientific perspective, while Jeff Bozanic and Ira Barocas added to the recreational diver's perspective.

During the Aqua-Corps TEC94 show in January of 1994, Abyss was demonstrated publicly to an audience of approximately 1,000 technical divers for the first time. At this time, it was still undetermined if the product could sustain full time commercial development, or be relegated to a specialty "enthusiast niche" as the other then existing dive planners had been. But the response from those who participated in the demonstrations at the TEC94 show was overwhelmingly positive and it was decided that ABYSS could become a commercial grade software package, with a full time development and sales team. Continued development occurred during the spring of 1994 with several more Beta versions being released and evaluated. Abysmal Diving was incorporated on June 1, 1994.

With the current release of Abyss, Advanced Dive Planning Software V2.20 in May 2000 (the 11th release so far), over 7 years of continuing testing, evaluation and modification are being brought to you.

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Overview of Abyss

Welcome to Abyss, Advanced Dive Planning Software. Abyss is the next generation in Technical Dive Planning Software and the most advanced dive planning tool ever created. This latest version of Abyss introduces a wide range of new and exciting features that were previously unavailable to desktop decompression planning. Through Abyss you will be able to make detailed plans and then perform a simulated dive based on that information. During the simulation Abyss will track and inform you of a wide variety of information to help you plan and execute your dive. Abyss is not intended or designed for the novice SCUBA diver, but rather for the experienced diver who wants to have a better understanding of their hyperbaric diving environment.

Abyss is composed of four basic components; Defaults, Tools, Logbooks and the Dive Planner. Each of these components provides you with a specific group of functions to help you plan your dive.

The Dive Planner:

This is the heart of Abyss and the place where your dive profile is created. The Dive Planner unites the information stored in Defaults with your dive plan. The Dive Planner is where you create a model (a real-time dive simulation) that integrates all of the information you have given to Abyss.

Defaults:

This is where you personalize Abyss to reflect all of your unique attributes. Abyss then takes this unique information into account for the many varied computations it runs by altering many of its internal equations. By carefully setting all of the Defaults, you are customizing Abyss to reflect you, as a unique diver with an individual style all your own. Thus no two versions of Abyss are quite the same, nor should any two Abyss tables be necessarily identical.

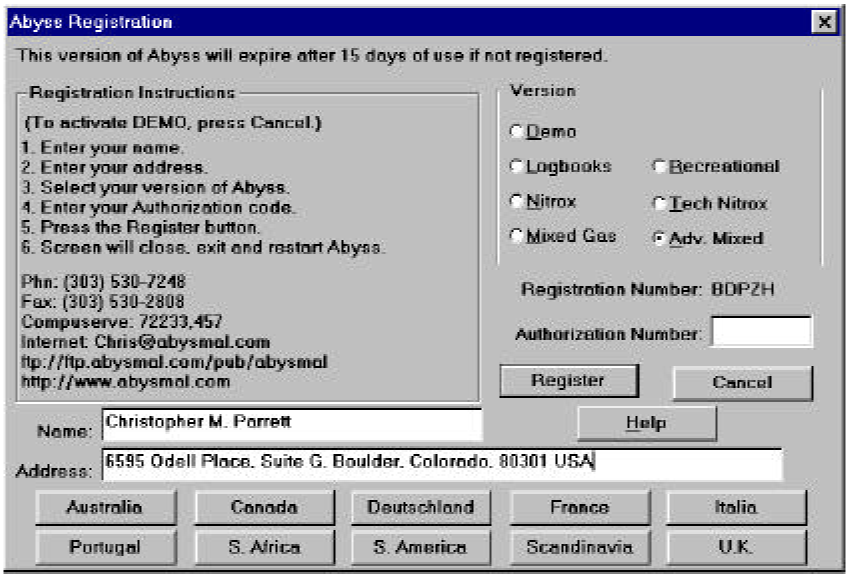
Tools:

Abyss provides you with a fast and friendly way of determining dive related information. The Tools section is a set of utilities tailor made just for divers. The Tools section is completely separate from the other components, and may be used at any time.

Logbooks:

Here Abyss provides you with an electronic version of your tried and true friend, the dive log. The Divelog is composed of over 20 separate log sheets, each of which is fully integrated with the others, and with the dive profiler. This allows you a fast and simple means to keep track of everything related to your dive.

Installation and Registration--*Dive Planner*



<u>Minimum System Requirements</u>

Abyss requires an IBM PC or 100% PC compatible,
4MB RAM, (8MB Recommended)
14MB Hard Drive Space
386SX CPU (Pentium Recommended)
A Mouse or other pointing device
Microsoft Windows 3.1(for 16bit V1.75 of Abyss), Windows 95/98 or Windows NT (for 32bit V2.00).
640x480x256 VGA Graphics (1280x1024x32K Optimum)

Setup Overview

The Abyss Setup program has been designed to minimize your effort and to fully automate the installation process as much as possible.

<u>The Abyss Setup program will Not</u>

1. Change or alter any of your driver settings
2. Add any fonts to your system
3. Change or alter your Autoexec.bat or Config.sys files
4. Write any information back to the Abyss setup diskettes
5. Alter any of your INI file settings in Windows.

<u>The Abyss Setup program Will</u>

1. Request you to confirm or specify a new target installation directory.
2. Allow you to cancel the installation at any time
3. Create a new program group and program icons
4. Create several Hidden/Write protected registration files in your abyss directory.

<u>Running The Abyss Setup</u>

Before you install your copy of Abyss on your PC we strongly recommend that you first exit any other programs you may be running under Windows. Failure to close all other programs “May” result in an partial or failed installation..

Windows 3.x Setup

1. Start Windows 3.x and shut down any other programs that may be running.

2. Insert the Abyss CD-ROM into your CD-ROM drive.

3. From the Program Manager in Windows select **FILE**.

4. Select **RUN**, then **BROWSE** from the options list.

5. Select which drive you are installing Abyss from in the DRIVES box, D or E.

6. Double click on the file name **Setup.exe**, and then click OK to begin the installation.

7. Follow the remaining onscreen installation instructions
   Abyss will now create the Abyss sub-directory and copy all required files into it for you.
   At the same time Abyss will create 3 additional sub-directories in the Abyss directory.
      Samples, where several sample dive profiles are stored.
      Dives, where all of your dive profiles will be stored.
      Templates, where all of your dive templates will be stored.

Windows 95/98/NT Setup

1. Start Windows 95 and shut down any other programs that may be running

2. Insert the Abyss CD into your CD-ROM drive.

3. From the **START** menu select **RUN,**

4. In the **Run** Dialog Box type, **Setup.EXE**

5. Follow the remaining onscreen installation instructions
   Abyss will now create the Abyss sub-directory and copy all required files into it for you.
   At the same time Abyss will create 3 additional sub-directories in the Abyss directory.
      Samples, where several sample dive profiles are stored.
      Dives, where all of your dive profiles will be stored.
      Templates, where all of your dive templates will be stored.

Registering Abyss

1. During the installation process Abyss will generate a unique **Registration number** on the HELP-REGISTRATION screen.
2. Write your Registration Number in the space provided on your User Agreement.
3. Carefully read, initial, and complete the Abyss User Agreement.

(The Abyss User Agreement is an important legally binding contract. It is most important that you take your time and fully read, understand and agree to all of the terms and conditions of this contract. Only After signing the Abyss User Agreement in ink and mailing the original back to Abysmal Diving will you be issued the Authorization Code to fully activate your copy.)

4. MAIL the complete Abyss User Agreement back to Abysmal Diving in the envelope we provide you. ***DO NOT FAX IT!***

DO NOT FAX your Signed User Agreement, it will NOT be accepted.

5. Once Abysmal Diving has received your original signed User Agreement we will notify you of your Authorization Number.
6. When you receive your Authorization Number select **HELP** and then **REGISTRATION** from the main menu in Abyss.
7. Select the version of Abyss you are using
8. Enter your complete name and address
9. Enter your Authorization Number
10. Press the Register Button causing the Registration screen to close.
11. That will complete the registration of your copy of Abyss, and insure you unlimited use.

Failure to register your copy of Abyss will cause it to stop working after the 30 day registration period has elapsed, during which it will be limited to 100ft or 30m.

Installation Support

If you have ANY problems at all don’t hesitate to contact us!

Phone in the USA, (303)-530-7248,
Fax in the USA (303)-530-2808,

e-mail: chris@abysmal.com

Getting Started

Once you have successfully installed Abyss, chances are that you are going to want to create a quick dive profile just to get a feel for what Abyss is all about. So, without going to the tutorial in the back of the manual, lets walk through a simple dive profile.

1st, from the menu bar select FILE, and then NEW.
This brings up the New Dive Profile window, and allows you to describe where you are and what you will be doing as soon as you hit the water.

2nd, as soon as you click the Okay button, the Dive Profile window opens, showing you a green dot in the upper left hand corner. That dot represents you on the surface before your dive. Now click the mouse pointer anywhere on the black portion of the screen, and you will open the New Waypoint screen. Fill in some random information, say 100ft or 30 meters and stay there for 25 minutes, now click the Okay button.

3rd, with the mouse pointer click along the very top of the Dive Profile window where the black portion of the screen ends, or on the Red Arrow Icon. This will bring up another New Waypoint screen, but the depth should read “0”. Click the Okay button and Abyss will take you to the surface.

What you now see is a very simple dive profile.
You have one waypoint on the surface to begin with, one waypoint on the bottom and a third and final waypoint back on the surface.

In essence this is all there is to Abyss. It is as simple, fast and friendly to use as you have just seen. Abyss can also be very complex and extremely detailed, *but how it operates is completely up to you.*

Now I invite you to sit down, relax and read through the rest of the manual. To fully appreciate all of the abilities of Abyss will probably take you some time, so don’t rush yourself through it. And should you ever feel helplessly confused or just have a simple question, *pick up the phone and give us a call.* <u>*We like hearing from other “Abysmal” divers*</u>.

And remember, most importantly of all

Diving is supposed to be FUN!!.

For most of us it is our recreation of choice.

Being in the water is what this is all about.

Abyss is here to make your diving a little safer and a little more pleasant.

<u>***So enjoy yourself and may all your dives be memorable***</u>.

Dive Planning Window—*The Abyss Desktop*

When Abyss begins you will be working in the Abyss desktop. This is the main area from which you run all of the Abyss features. As soon as you have opened a Dive Profile you will then be in the Dive Planning Window, which is the graphical environment in which you create each of your waypoints and run the dive simulation.

1. **Depth Scale:**

Along the left hand side of the Dive Planning Window is the depth scale. The incremental value can be changed in two ways. In File-Scaling you can set it to a fixed value of your choice, or after turning Automatic scaling OFF, you can place your mouse pointer on top of the word DEPTH, and click your left and right mouse buttons to alter the scale on the fly.

2. **Time Scale:**

Along the top of the Dive Planning Window is the Time scale. The incremental value can be changed in two ways. In File-Scaling you can set it to a fixed value of your choice, or after turning Automatic scaling OFF, you can place your mouse pointer on top of the word TIME, and click your left and right mouse buttons to alter the scale on the fly.

3. Mouse Position:

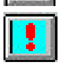
In the bottom right hand corner of the Dive Planning Window are two values. The first is your mouse pointer's current depth, and the second is it's time. This allows you to position the mouse in a specific time/depth combination before you click to open a New Waypoint. The values that are displayed in these fields, will be transferred to your Time and Depth fields in the New Waypoint screen

4. **Tool Bar:**

On the tool bar you will find three non standard icons in addition to the standard Windows control icons.

A.  The **Red Arrow**: Tells Abyss to insert the next waypoint at the surface (depth = 0, time = 0.25)

B.  The **Dot**: Tell abyss to insert a generic New Waypoint immediately after your current waypoint.

C.  The **Exclamation Mark**: Tell Abyss to perform a Recalculation of the entire dive profile.

D.  The **Deep Stop**. Tells Abyss to add a series of Deep Stops to the normal Deco Schedule.

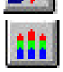
E.  **Warning Triangle**.

This feature allows to "Turn-Off" all of the warnings generated from exceeding your PPO2 / END, Required Decompression Stops, and Hypoxia alarms. This can be very helpful for running faster simulations during the modification of a completed profile, but great caution must be used as Abyss will not alert you to any possible dangers. We recommend that this option be left enabled at all times.

F.  **Stick Figure** .

This feature allows to "Turn-Off" all of the default waypoints generated from Descent/Ascent rate changes, Deco gas changes, and Workload changes. This will also disable the effect of the Personal & Thermal defaults, as well as the workload Thermal Boosters and Workload half-time modifiers. This can be very helpful for running faster simulations, or for use in training.

G.  **Tissue Display**. Enables or Disables the Real-time tissue display option.

H.  **Zoom Factor**. Sets the magnification of the tissue bars in the tissue window.

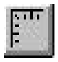
I.  **Calculation Interval**. Sets the mathematical precision of Abyss, allows for matching to the deco interval.

J. 

Units.

The Units screen allows you to select either the Metric (BAR/Liter/Meter) or the Imperial (Foot/PSI/Cubic Feet) system of measurement. Once either of these has been selected, all other screens in Abyss (except tools) will convert to the selected format**.** This feature can be modified from the Dive Profile Window allowing you to move between Imperial and Metric units in the same dive.

This section applies to All versions.

K.  **Auto Scaling**. Controls if the Time and Depth increments on the dive profile window are scaled automatically.

5. **Waypoints:**

A. **White:** This is a user defined waypoint that can be modified.

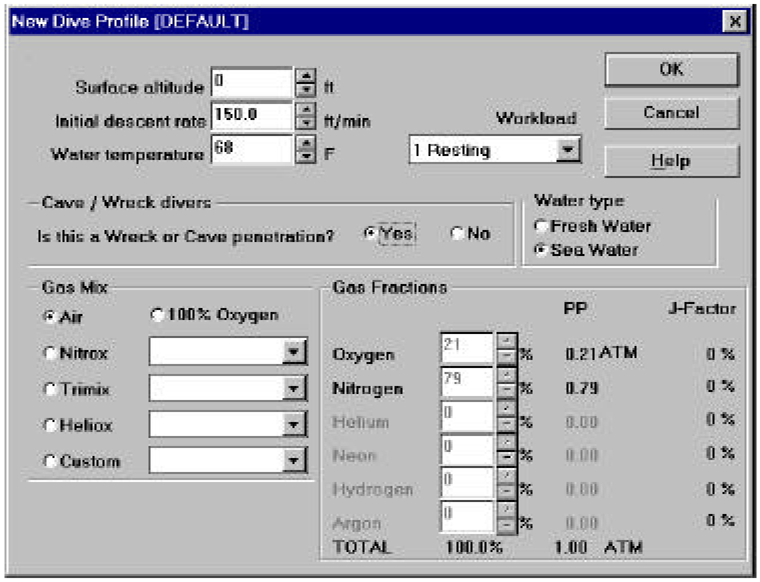
B. **Yellow:** This is a defaults generated waypoint that was created based upon a change in Descent/Ascent rates, Deco Gas Change, or Workload, and can not be modified.

C. **Blue:** This is a Decompression waypoint, and can not be modified.

6. **Decompression Ceiling:**

Is displayed as a red line that follows above your dive profile. This line represents the minimum depth you could ascend to from any point in the dive before decompression is required. Normally this is a series of straight lines that follow above each of the waypoints. For an accurate representation of true ceilings that vary throughout the dive profile, the "real-time" display option MUST be used (click on the Tissue-Display Icon).

Opening a New Dive Profile window



By selecting "File/New" from the menu bar you begin the process of creating a new dive profile. Upon selecting this, Abyss will open a new dialog entitled [New Dive Profile]. In this window you will be required to answer the following questions;

1. **<u>Surface Altitude:</u>**

The altitude at which the dive will take place.

ex. 2,500ft, 1000m or 0ft/m (at the surface of the ocean).

2. **<u>Initial Descent Rate:</u>**

Your initial rate of descent from the surface to your first waypoint.

{Note, you must enter a number from 1 to 150, "0" is not allowed}.

3. **<u>Water Temperature:</u>**

This will allow Abyss to track the changes in the temperature of the water and use this data, in conjunction with Defaults-Thermal, to estimate your loss of body temperature during your dive.

4. **<u>Workload Modifier:</u>**

The Workload Modifier is used to allow Abyss to calculate your ongassing and offgassing, estimated gas consumption & best gas to breathe, based upon the fact that as your level of activity increases, so does your demand for breathing gas. This is one of the advanced features of Abyss, and is normally left at a setting of (1 Resting). If you are planning a more advanced dive and wish to take advantage of ABYSS' automated gas consumption estimation features you will need to make this as accurate as possible. Five choices are offered:

Rest/Normal, *finning with little effort, or hanging on decompression.*
Mild, *finning with some effort, more "active" diving.*
Moderate, *finning against a current, some exertion.*
Heavy, *finning hard, working while diving.*
Extreme, *finning as hard as you can, heavy breathing*

This information, coupled with your RMV from (Defaults-SAC) will allow Abyss to accurately estimate your gas needs.

5. **<u>Is this a Wreck or Cave penetration?</u>**

This information is used in the generation of your gas consumption tables. As a penetration dive does not always allow direct access to the surface, Abyss needs to know from which points you want to calculate additional gas reserves. If you answer yes, you will be asked on every New Waypoint screen if you can ascend to the surface from that point.

6. **<u>Water Type:</u>**

Allows you to specify either Fresh or Salt water. This allows Abyss to correct the pressure used in calculations.

7. **Gas Mix**

Enter the initial gas you will be breathing while descending from the surface to your first waypoint. The gas percentage can be entered to 1 decimal place accuracy (exp. 15.1%), but Abyss will only display whole numbers (15%) on the screen You can select one of the preset gas mixes, (depending on your version of Abyss) Air, Nitrox, Heliox, Trimix, 100% Oxygen., or use the Custom button to define a unique gas mixture.

If you have defined your custom gas mixes in the Defaults section, then by selecting one of the Nitrox/Trimix/Heliox/Custom buttons you will have the option of opening a list box next to them and selecting one of your predefined gases..

Once you have selected your breathing gas the Gas Fractions box will display the percentage of each individual gas in your mix, as well as the Partial Pressure of each gas in ATMs or BAR. This information will be highly useful in controlling your exposure to the deleterious effects of the various gasses.

8. **Partial Pressure:**

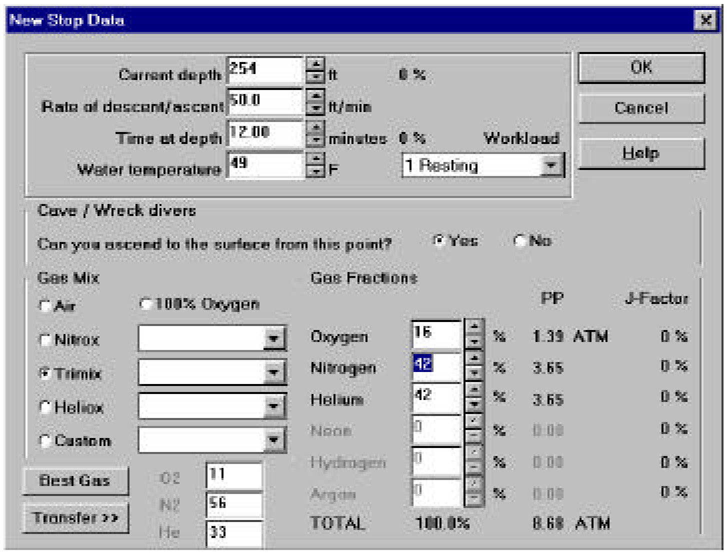
This is the partial pressure for the fraction of each gas at the current depth.

9. J-Factors

This displays any adjustments that you have requested be made to your entered data from the Defaults-J-Factors screen, as a positive or negative percentage (+10%, -15%) to the right of each of the gases,.

Once you have completed the New Dive Profile window, Abyss will move you from the pre-dive environment to the dive planning environment. This section of Abyss is made up of two components; the dive planning window and the 32 compartment tissue array.

Creating a New Waypoint



The New Waypoint screen contains essentially the same information as the New Dive Profile Window. This is the screen that you will use to define each individual waypoint throughout the remainder of your dive. ***It is important to remember that all events occur from the waypoint forward, or to the right of the point on your screen. When defining a waypoint you are telling Abyss what will be happening from this waypoint (your current position) forward to <u>the instant before</u> you arrive at the next waypoint.***

Upon creating a new waypoint, you are telling Abyss;

1. **<u>Current Depth</u>**, The depth of the waypoint
2. **<u>Rate of Ascent/Descent</u>**, Your rate of Ascent or Descent from this waypoint to the next.
3. **<u>Time At</u>**, The time you intend on spending at that waypoint.
4. **<u>Water Temp</u>**., The water temperature.
5. **<u>Workload</u>**, Your level of physical activity (Workload).
6. **<u>Gas Mix</u>**, The gas you are breathing.
7. **<u>Gas Fraction</u>**, the percentages of the individual gases in your gas mix. You are also telling Abyss the gas that you will be breathing upon your departure from this waypoint and upon arrival at your next waypoint, as well as the rate of Ascent or Descent from this waypoint to your next waypoint.

It is VERY important that you understand these last two items*, as they may have a significant impact on technical dives. If you do NOT want to use the current waypoint's Gas or Ascent/Descent data to make a transition to the next waypoint, you MUST create another waypoint immediately after this one containing the information you want to use.*

Exp. At a certain waypoint you are breathing Gas "X". Upon leaving this waypoint you are STILL breathing Gas "X" until you arrive at the next waypoint. If Gas "X" is not appropriate for that Ascent or Descent you must indicate this to Abyss through the use of another waypoint. Remember, when you are ready to surface enter the last waypoint at a depth of Zero feet/meters, or press the Red Arrow Icon. This tells Abyss to bring you to the surface and perform any needed decompression.

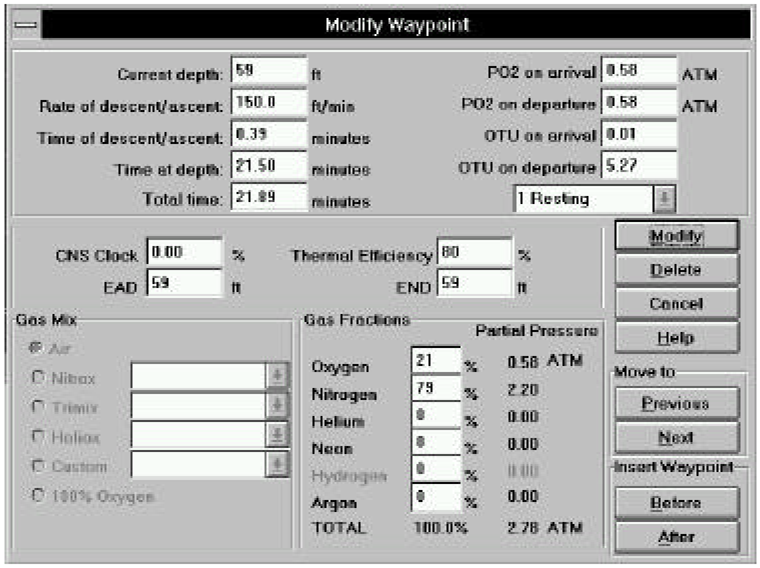
8. **<u>Best Gas Button</u>**, generates an optimum gas mixture based upon the following. (active for Tech Nitrox and above only) Current Depth, Gas Mix selected (Custom, Heliox, Nitrox or Trimix) , Current phase of the dive (Descent, Bottom, Ascent, Deco) Defaults, Gas Optimization, PPO2 and END desired. *Best Gas does NOT take into account Workload, Next depth, CNS Clock, OTUs, PPO2/END limits, or Defaults- Gas Optimization- PPO2 and END May Vary By or Not To Exceed values.*

9. **<u>Transfer Button</u>**, moves the new gas percentages generated from the Best Gas button into the active Gas Fraction fields for use by Abyss.

10. **J-Factors**

This displays any adjustments that you have requested be made to your entered data from the Defaults-J-Factors screen, as a positive or negative percentage (+10%, -15%) to the right of each of the gases, Current Depth and Time At fields.

Modifying a Waypoint



The modify waypoint screen is an informational screen that displays all relevant data concerning a waypoint. Nothing on this screen can be changed while viewing it. Instead you are presented with a series of buttons along the right hand side that will move you to the correct screen for what ever actions you deem necessary. **To open the Modify Waypoint screen simply click on any white waypoint with the left mouse button**. (waypoints are also dragable, simply place your mouse pointer on a waypoint, depress and hold down the left mouse button, and you can modify the time & depth without opening the Modify Screen). *You cannot modify a Blue Decompression or Yellow Defaults waypoint, though you can view them.*

Modify	moves you to the New Stop Data screen so modifications can be made.
Delete	deletes this Waypoint.
Cancel	returns you to the Dive Profile screen.
Help	gives you assistance with this screen.
Previous	allows you to view the previous Waypoint.
Next	allows you to view the next Waypoint.
Before	Causes Abyss to create a New Waypoint immediately before this one.
After	Causes Abyss to create a New Waypoint immediately after this one.

1. **Modifying the Current Depth:**
   Modifying "current depth" forces Abyss to move the waypoint to the new depth and recalculate all computations. An alternate means of modifying your current depth is to Click on the Waypoint and Drag it. While doing this look to the bottom right-hand corner of the Dive profile Window for a display of your current depth.

2. **Modifying Time To Depth:**
   This is a non-modifiable field and displays information only. It indicates the time required to move from your last waypoint to your current waypoint. This time can be changed by modifying your "descent/ascent rate".

3. **Modifying the Descent/Ascent Rate:**
   Modifying the "Descent/Ascent rate" forces Abyss to recompute the amount of time required to reach the waypoint.

4. **Modifying Time at Depth:**
   Modifying "Time at Depth" forces Abyss to alter the amount of time spent at the indicated depth.
   An alternate means of modifying your current time is to Click on the Waypoint and Drag it. While doing this look to the bottom right-hand corner of the Dive Profile Window for a display of your current time.

5. **Total Time:**

This is a non-modifiable field and displays information only. Total Time indicates the total time spent in the dive profile up to and including this point.

6. **Arrival PPO2:**

This is a non-modifiable field and displays information only. Arrival PPO2 indicates the Partial Pressure of Oxygen that you are exposed to upon arrival at the waypoint. Note: This reflects the breathing gas used just prior to this waypoint, which may not be the same as the gas you selected to begin breathing upon arrival at this waypoint. This value can be changed by varying the percentage of the oxygen in your breathing gas.

7. **Arrival OTUs:**

This is a non-modifiable field and displays information only. Arrival OTUs indicate your total (cumulative) Oxygen Toxicity Units that you have earned upon arrival at this waypoint.

8. **Departing PPO2:**

This is a non-modifiable field and displays information only. Departing PPO2 indicates the Partial Pressure of Oxygen that you are exposed to upon departing from this waypoint. This reflects the breathing gas used while at the waypoint, which will be the same gas you breath while traveling to your next waypoint. This value can be changed by varying the percentage of the oxygen in your breathing gas.

9. **Departing OTUs:**

This is a non-modifiable field and displays information only. Departing OTUs indicate your total (cumulative) Oxygen Toxicity Units that you have earned upon departing from this waypoint

10. **Modifying Gas Mixes:**

This allows you to chose from a selection of pre-defined gas mixes, or "Custom" to modify your current selection. Remember, when selecting a gas in a new waypoint you are telling Abyss what gas you will be breathing AFTER you have arrived at that point. Ex. if you select "Air" as the breathing gas on the surface, then insert a waypoint at 100fsw and choose Nitrox. Abyss will calculate ongassing based on breathing air on the descent and Nitrox upon arrival and for the remainder of time spent at that waypoint.

11. **Modifying Gas Percentages:**

Your breathing mixture is the sum of all the fractions of the various gases you have selected. If you select "Air" the fractions will be locked in and unmodifiable, as Air has a fixed fraction of Nitrogen and Oxygen. The same holds true for EAN32 & EAN36. If you select "Custom" you will be allowed to enter any set of gas fractions that total 100%. It is important to remember when selecting a gas in a new waypoint you are telling Abyss what gas you will be breathing AFTER you have arrived at that point. Ex if you select "air" as the breathing gas on the surface, then insert a waypoint at 100fsw and choose EAN32, Abyss will calculate ongassing based on breathing air on the descent and EAN32 upon arrival and for the remainder of time spent at that waypoint.

12. **CNS Clock:**

This is a non-modifiable field and displays information only. This is your Central Nervous System Oxygen Toxicity clock. The CNS Clock counts (as a percentage from 0-100% or more) the amount of exposure you have accumulated to the deleterious effects of hyperbaric Oxygen.

Tech Note*: Your dive should be completed in advance of the clock reaching 100% under normal circumstances if possible. As the clock approaches or exceeds 100%, your risk for a "CNS O2 Hit" greatly increases.*

13. **Thermal Efficiency:**

This displays your current thermal efficiency on a scale of 0-100. This value is derived from Water Temp, Workload, Defaults-Personal & Thermal. Abyss uses this value to compensate for thermal loss.

14. **EAD:**

This is a non-modifiable field and displays information only. This is your Equivalent Air Depth. This figure is useful when breathing a Nitrox gas mixture, and planning the dive as though you were breathing Air on a fixed table. It is provided solely for your convenience, and has no practical application in Abyss. In the event that your breathing gas is not a Nitrox mixture this field will display "N/A".

15. **END:**

This is a non-modifiable field and displays information only. This is your Equivalent Narcotic Depth. As many divers base their bottom gas mix on the level of tolerable narcosis, this figure gives you the equivalent narcotic depth for all of the gas components of your breathing gas as though you were breathing Air. Thus you may be at a depth of 220 feet on a Trimix, and your END may read shallower.

Tech Note*:*

Oxygen is about twice as lipid soluble as nitrogen, so it should theoretically be twice as narcotic. A very limited, controlled study suggests that oxygen is equipotent to nitrogen, and that the reason is possibly that much oxygen is bound to Hb, and is metabolized in the tissues. The weakness of this assumption is that oxygen and nitrogen may not be equally narcotic across all ratios and at all depths.

Abyss uses the following relative narcotic values when computing your END, unless you have selected Oxygen as Non-

Narcotic in Defaults-CNS-exceptional:
Helium = 0, Neon = 0.28, Hydrogen = 0.55, Nitrogen = 1.00, Oxygen = 1.00, Argon = 2.33

Repetitive Dives

If making more than one dive in a 24 hour period, or multiple dives over the course of several days, you will want to be able to track your ongoing level of saturation. The repetitive dive window allows you to have multiple dive displayed simultaneously, so that they will share your tissue saturation information over any period of time you require.

Repetitive dives are created by surfacing to a depth of 0, and indicating any time greater than 1 minute. When Abyss sees that you are on the surface, and your time is greater than 1 minute it will ask you if you want to make a repetitive dive. If you answer yes, it will ask two additional questions.

1. **Your surface interval time for all gases breathed**:

    You need to enter the entire time you will be on the surface, regardless of what gas you are breathing.
    Abyss uses this information to determine a post dive maximum bubble nucleation probability.
    As a default value, Abyss will display the time you entered in the New Waypoint screen.

2. **What is your next Maximum depth:**

    The maximum depth that you will descend to on the next dive.
    Abyss uses this information to determine bubble crushing and possible reseeding/renucleation.

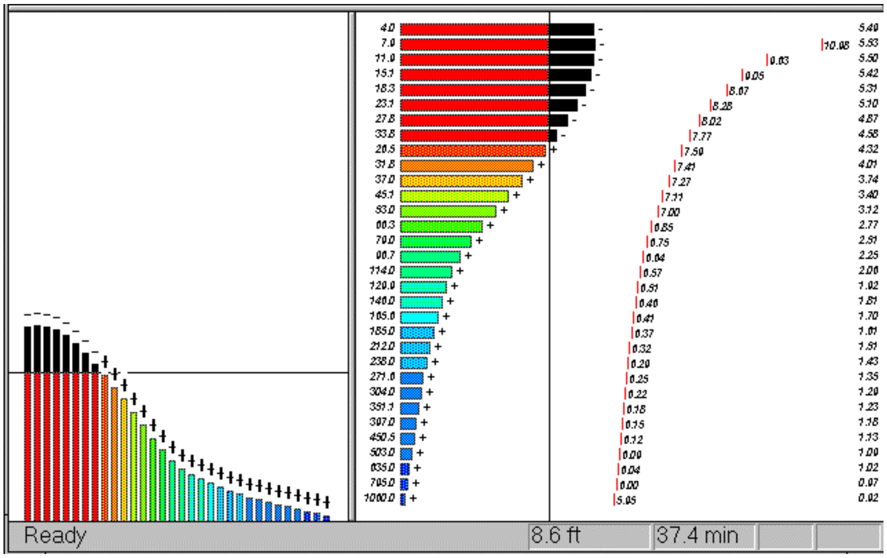
These two pieces of information are used by Abyss to select from one of 216 repetitive dive "a" "b" value arrays. These arrays will control your offgassing during the surface interval, and your ongassing/offgassing and deco for your repetitive dive. Once you have answered these questions, you must still enter a waypoint or multiple waypoints for your surface activities. While on the surface you may make a gas switch if needed. Make sure your surface waypoints match the time you indicated in the repetitive questionnaire, and that your next dive does ***Not*** exceed your maximum indicated depth.

Access to the repetitive questionnaire can not be had after you have surfaced, so take your time when you enter the information. ***The only way to change this information is to delete your surface point and then insert a new one***. For the computation of repetitive diving Abyss now uses a proprietary implementation of the RGBM (Reduced Gradient Bubble model) tracking dissolved and free gas phases. This allows Abyss to track the growth and formation of post dive bubbles as well as tissue tensions. At this time, no other program in the world offers this level of dual modeling.

Tech Note:

*When making a repetitive dive, **NEVER** modify a surface waypoint.*
*If you need to change the information, **DELETE the surface waypoint**, and insert a new one.*
Failure to do this will cause Abyss to become confused and result in incorrect usage of the RGBM Model.

Tissue Array



The 32 compartment tissue array provides a graphical representation of your theoretical tissue saturation. The fastest tissues are displayed on the left/top and the slowest on the right/bottom. Typically, this will result in a wave or bulge toward the left side/top of the array during the dive, and a much smaller wave or bulge towards the right side/bottom of the array at the end of the dive.. This is due to the fact that the faster tissues will ongas and offgas at a higher rate than the slower tissues.

1. **<u>Scaling and Sizing</u>:**
The tissue array is contained in a "splitter" window. This allows you to increase or decrease the amount of total screen space used by the tissue window without affecting the contents of the tissue window itself. In addition, the tissue bars can be magnified or reduced by selecting "File-Scaling" from the menu bar and changing the scale rate. To size the splitter window move your mouse pointer over to the top of the window until it changes to 2 parallel horizontal bars, then click the left mouse button and drag to your desired size.

2. **<u>Real Time</u>**:
This will allow you to see the actual ongassing/offgassing taking place as Abyss calculates it in real-time (30 second intervals). Selecting real-time will greatly reduce the speed at which Abyss runs, but offers you a much better visual display of what is actually happening. To initiate real-time, select it from the "File-Scaling" window, or the menu bar icon.

Note: For best possible display results, set the Calc Interval to 1, and select real-time. This will force Abyss to calculate all ongassing and offgassing during your descent and ascent, and display that information to the tissue window.

3. **<u>Bar Color</u>:**
All bars begin as Blue, and are at zero saturation and end as Red at full saturation. As saturation increases, the bar color shifts from blue to green to yellow to red. Supersaturation is indicated as Black, and displays those compartments that have entered into a state of decompression during an ascent.

4. **<u>Bar Height</u>:**
All bars begin at the bottom/left of the array. As they ongas the bar lengthens to show the amount of gas loading that has taken place. The longer the bar, the more dissolved gas it contains. This is a summary of all the gases in that compartment.

5. **<u>(+) and (-)</u>:**
Indicates whether the tissue compartment is ongasing (+) or offgasing (-).

6. **Saturation Line:**

This thin black line indicates the saturation limit for any given depth for the specific gas mixture you are using. If you remained at a specific depth long enough, all 32 tissue bars would rise to, but not above, this line. As you descend this line will rise (allowing room for more ongasing). As you ascend this line will drop (possibly requiring decompression). When a tissue bar crosses over this line (and becomes black), a state of tissue supersaturation exists, and decompression must take place to safely ascend.

Note*, even when a compartment is fully saturated, this value will not be equal to the ambient pressure (depth). This is because you always have some fraction of Oxygen in your gas mixture that is acting to reduce the total pressure of the inspired gas. Were you to breathe a pure gas, such as 100% Nitrogen, then this value would indicate your current depth in pressure.*

7. **Compartmental Half-Time:**

Is displayed to the left of each tissue bar, and is adjusted to accurately represent the contents of more than one gas in the compartment, by means of a weighted average of the individual gas half-times from Defaults-Algorithm Controls-Halftimes. Thus these half times may not match any of the individual halftimes listed in Defaults-Algorithm Controls-Halftimes. Changes to your breathing gas, ongassing or offgassing status and workload will effect these values and may cause them to change from Waypoint to Waypoint throughout the entire dive.

8. **Maximum Allowable Overpressure**:

Is displayed to the right of the small Red Bars. These are the controlling values that force you into a deco stop, and limit your ability to ascend. This value, displayed in “bar” pressure units, tells you how much additional pressure a compartment can momentarily tolerate without resulting in injury. During normal decompression you will see these small red bars come to the edge of the tissue bars, but not enter into the tissue bars. Each time a red bar touches a tissue bar, a blue decompression point is generated by Abyss. Should one of these enter into the area of a tissue bar, a decompression violation has occurred.

Note*. having your Template-Calc Interval and your Defaults-Decompression-Deco Interval set to unmatching values may result in apparent deco violations on the screen. This is solely a display based error. To maintain display integrity, be sure to set both values to the same increment.*

9. **Compartmental Pressure**:

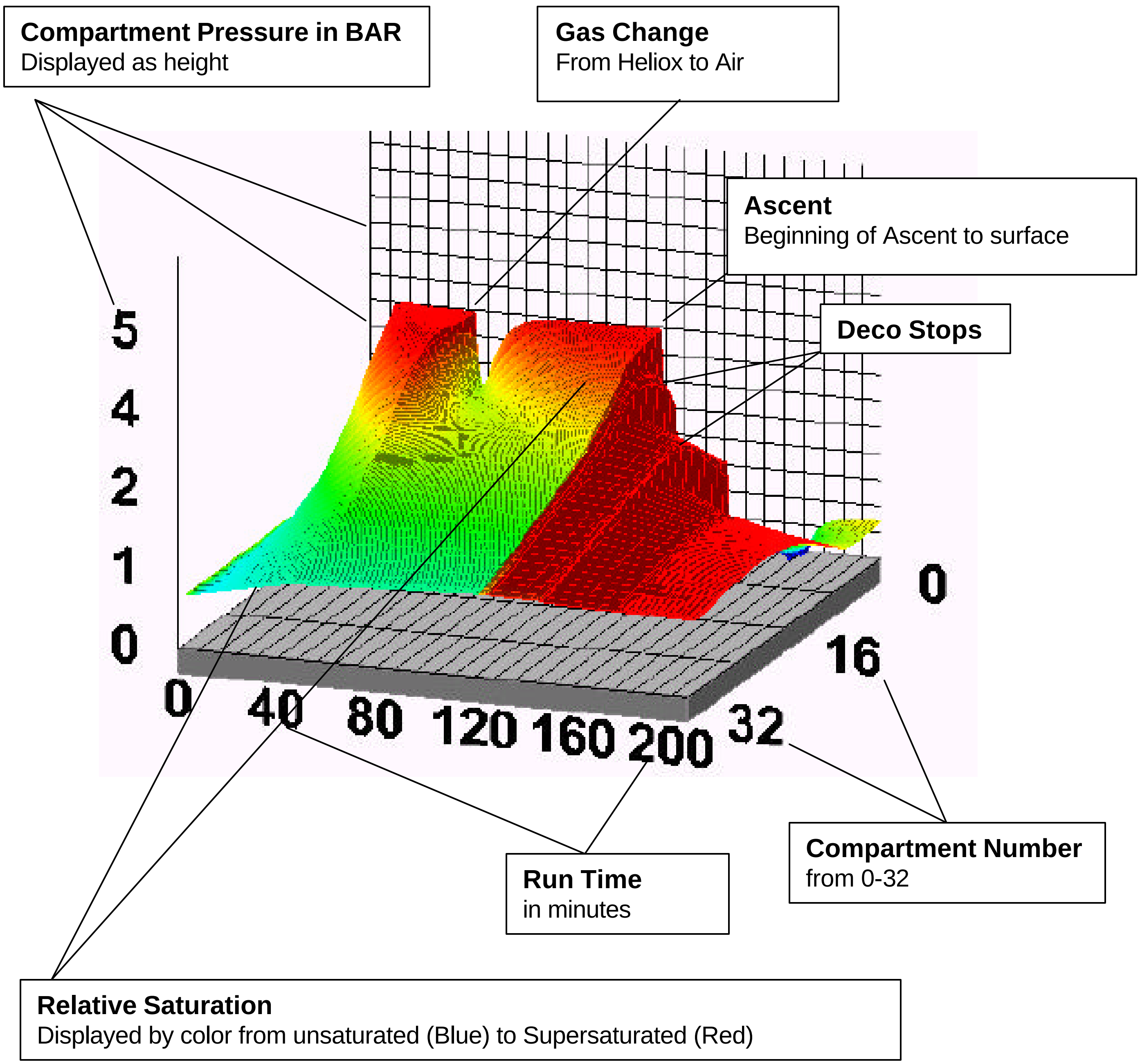
Is displayed to the far right of the tissue bar. This is the total pressure of all the gases in the compartment. All values displayed here are in "bar” pressure units , and are not convertible using the Units option in Abyss. Even when a compartment is fully saturated, this value will not be equal to the ambient pressure (depth). This is because you always have some fraction of Oxygen in your gas mixture that is acting to reduce the total pressure.

10. **Decompression Ceiling:**

Is displayed as a red line that follows above your dive profile. This line represents the minimum depth you could ascend to from any point in the dive before decompression is required. Normally this is a series straight lines. For a more accurate representation of true ceilings that vary throughout the dive profile, the “real-time” display option in Template-Scaling MUST be used..

3D Tissue Graph

The all new 3D Graph allows you to visualize your entire dive, from start to finish at a glance. Where the Tissue window displays for only one moment in time, the 3D Graph displays your dive profile from beginning to end. The purpose of the graph is to allow you better analyze the impact of gas changes, depth changes, and decompression stops on the disolved gas pressure in your body. As you look at the graph pay special attention to steep drop offs showing rapid ascents, multiple peaks on a single dive showing gas changes from a "Fast" gas to a "Slow" gas. The resolution of this display is greatly enhanced when the REAL-TIME option is used on the Tissue Array. All information on this graph comes from the values generated in the Tissue Array, so all Tissue Array control options impact this display. A zoom feature is available by Left clicking yourmouse on any point of the graph. Notice that the time scale on the bottom of the graph will change after you have zoomed.



DEFAULTS-- Algorithm Controls-*Algorithm*

The algorithm section allows you to choose which mathematical model Abyss will use to compute your ongassing and offgassing during your dive. The Algorithm defaults currently allows you to choose from three Buhlmanian algorithms with RGBM constraints, and a pure RGBM algo to compute your Ongassing/Offgassing and Decompression. The reasoning behind the Asymmetrical vs. Symmetrical models is to control the rate of offgassing. A symmetrical model allows for the offgassing to take place at the same rate as the ongassing did. An Asymmetrical model adds additional time to the offgassing, while not affecting the ongassing. Over the last several years most people have moved to the asymmetrical style models as they seem to more accurately predict what is actually happening during decompression. For the most part, the major point of discussion is to what degree the model should be asymmetrical, and this is why we offer you 2 asymmetrical models to choose from. One for less aggressive dives, and one for more aggressive dives.

Abyss-150. (Most conservative, longest deco times)

32 compartment, Asymmetrical multi-gas algorithm that is used as **the default in Abyss**.
Offgasing halftimes are 150% of Ongassing Halftimes, (50% longer).
Halftimes and "a" "b" values are proprietary Abyss values.
This algorithm is optimized and recommended for aggressive Technical and Mixed Gas diving.

Abyss-120. (Average conservatism, average deco times)

30 compartment, Asymmetrical multi-gas algorithm.
Offgassing halftimes are 120% of Ongassing Halftimes, (25% longer).
Halftimes and "a" "b" values are original Buhlmann values, with very minor extrapolations.
This algorithm is similar to the current Buhlmann ZH-L16c of 1993 or its newer ADT derivative of 1995.
This algorithm is optimized and recommended for general recreational and technical diving.

Abyss-100 (Most liberal, shortest deco times)

30 compartment, Symmetrical multi-gas algorithm.
Offgassing halftimes are equal to Ongassing Halftimes.
Halftimes and "A" "B" values are original Buhlmann values, with very minor extrapolations.
This algorithm is similar to the original Buhlmann ZH-L12 of 1983.
This algorithm is for non-aggressive (No-Deco) recreational diving.

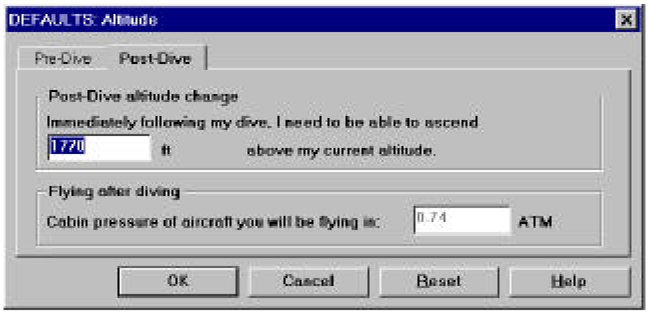
Abyss-RGBM (Newest Experimental bubble model, *accelerated deco with very short deco times*)

The Reduced Gradient Bubble Model (RGBM) is a dual phase (dissolved and free gas) algorithm that incorporates and couples historical Haldanian dissolved gas transport with bubble excitation and growth, treating both the dissolved and free phase transfer mechanisms, postulating the existence of micropockets of gas seeds (micronuclei) with pressure permeable elastic skins of surface active molecules small enough to remain in solution and strong enough to resist collapse.

RGBM uses equation of state (EOS) for bubble skins in the impermeable region, transitioning pressure response from "crumbling" to "thin film" for bubbles while tracking Boyle-like phase response under compression-decompression in permeable and semi-permeable bubble regions and pre-conditioning excitation phase volumes to depth and gas mixture.

This algorithm is optimized for aggressive Mixed Gas diving.

DEFAULTS--*Altitude*



Pre-Dive tab

1. **<u>Initial altitude before traveling to dive site:</u>**
Enter the altitude where you spent the last 12 hours.
This is used to determine your initial saturation level.

2. **<u>Final Altitude at dive site:</u>**
Enter the elevation of your dive site.
This is used to determine the altitude where desaturation occurs.

3. **<u>Total time from departure to beginning of dive:</u>**
Enter the time you spent traveling to the dive site, and time at the site before entering the water.
This is used to determine the amount of pre-dive offgassing that has occurred, and to set the initial tissue saturation levels for the dive.

Post Dive tab

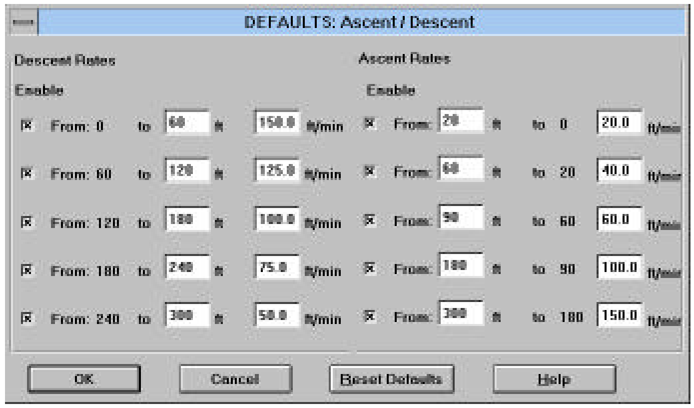
1. **<u>Immediately following my dive, I need to be able to ascend to:</u>**
Allows you to specify a change in altitude immediately following your dive. Use this feature to indicate that you will be going through a mountain pass, or from a low altitude to a higher altitude. As a safety factor, this value is set to 1,770ft or 540m, and ***should not*** be set lower without due caution. This value controls the surface pressure that Abyss uses to compute your final allowable overpressure (supersaturation) before getting out of the water. Lowering this value from (1,770ft/540m) will result in much shorter deco stops at the shallower intervals.

Tech Note !!:
Setting this value to "0ft/0m" removes <u>all altitude safety</u>, and places you at an increased risk of DCS from ANY change in elevation, or increase in post-dive stress. If you decide to lower this value, please be certain that there will be little or no change in elevation, and that upon exiting the water there will be very little or NO physical work for the next few hours.

Exp. You are making a dive at sea level, but enroute to your home you must drive over a mountain pass of 3,500ft. By setting the Elevation Change to 3,500ft, you are instructing Abyss to calculate additional decompression to allow you to tolerate the drop in atmospheric pressure from the change in elevation without substantially increasing your DCS risk.

2. **<u>Cabin pressure of aircraft you will be flying in:</u>**
If you wish Abyss to calculate your "Time-to-Fly", enter the level of pressurization the aircraft maintains. Abyss will then calculate the additional offgassing time required for you to be able to withstand a drop in atmospheric pressure to the cabin pressure of the aircraft. As a rule 8,000ft is standard in many commercial jet aircraft.

DEFAULTS--*Descent / Ascent*



This default screen allows to indicate your standard rates of Descent and Ascent depending on your depth. When filled out, Abyss will use these figures as your default values while planning a dive. In the Descent section each rate you enter in the “To” column will be automatically carried over to the next “From” column, while in the Ascent section each rate you enter in the “From” column will be automatically carried over to the “To” column. This insures that you maintain a consistent range of depth coverage and do not skip a range by accident.

The maximum rate of descent or Ascent is 150 ft/min. or 45 m/min.

Descent tab

1. **<u>Descent From:</u>**
Ex. I descend from 0-60ft at 100 ft/min.
60-100ft at 60ft/min.
100-200ft at 40ft/min.

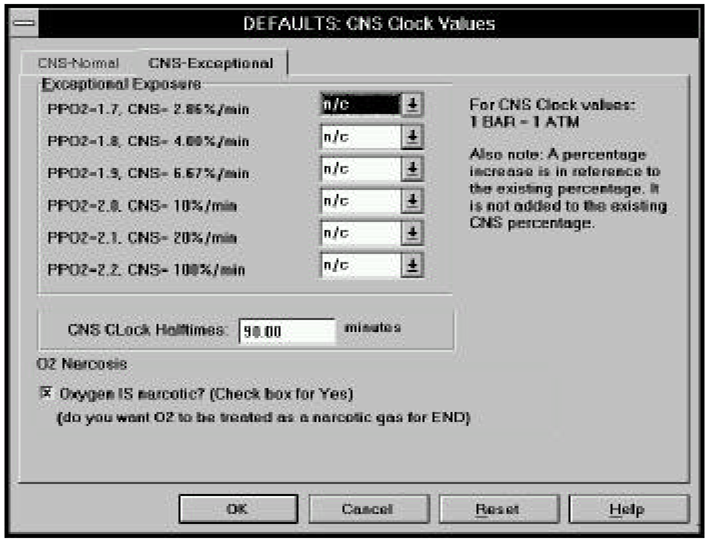
Ascent tab

2. **<u>Ascent From:</u>**
Ex. I ascend from 20-0ft at 20ft/min.
60-20ft at 40ft/min.
100-60ft at 60ft/min.

3. **<u>Enable:</u>**
This allows you to selectively enable or disable each range of Descent/Ascent settings.
Should you desire to disable all Descent/Ascent setting, but retain other defaults, click on each checkbox to remove the “X”.

***Tech Note**:*
These values will show up on your dive profile screen as <u>Yellow Waypoints</u>

DEFAULTS—Limits-*CNS Clock*



One of the advanced features of Abyss is the automated tracking of your CNS O2 exposure, commonly called your CNS Clock. If after significant diving experience you have established your own ability to tolerate oxygen under pressure you may decide to alter the values that Abyss uses to calculate your CNS minutes. For each exposure level from a PPO2 of 0.6 ATM to 2.2ATM/BAR Abyss allows you to modify the clock settings by a (+) factor of 10%, 25%, 50%, 75% or 99%.

{***NOTE****: For the purposes of the CNS Clock only, 1 ATM is considered the same as 1 BAR.}*

Normal Tab:

1. PPO2 = **0.6atm 0.14%** for every minute you remain at this exposure level.
2. PPO2 = **0.7atm 0.17%**
3. PPO2 = **0.8atm 0.22%**
4. PPO2 = **0.9atm 0.28%**
5. PPO2 = **1.0atm 0.33%**
6. PPO2 = **1.1atm 0.42%**
7. PPO2 = **1.2atm 0.48%**
8. PPO2 = **1.3atm 0.55%**
9. PPO2 = **1.4atm 0.67%**
10. PPO2 = **1.5atm 0.83%,** Please use caution in this PPO2 range.
11. PPO2 = **1.6atm 2.22%**.

Exceptional Tab:

12. PPO2 = ***1.7atm 2.86%*****, Very High PPO2 Exposure range, High Danger**
13. PPO2 = ***1.8atm 4.00%***
14. PPO2 = ***1.9atm 6.67%***
15. PPO2 = ***2.0atm 10.00%, Extreme PPO2 Exposure range, Extreme Danger***
16. PPO2 = ***2.1atm 20.00%***
17. PPO2 = ***2.2atm 100.00%***

Ex. At a PPO2 of 1.6 ATM your CNS clock ticks at 2.22% for every minute you remain at that exposure level. By selecting a modification of +10% your new clock rate will be 2.44%, thus increasing your safety factor by 10%.

18. **CNS Clock Halftime**

The number of minutes spent on the surface while breathing Air, before 1/2 of the CNS clock cumulative value will be reduced for repetitive dives. For each half-time spent on the surface the CNS Clock will drop by 50%.

19. **Oxygen is Narcotic:**

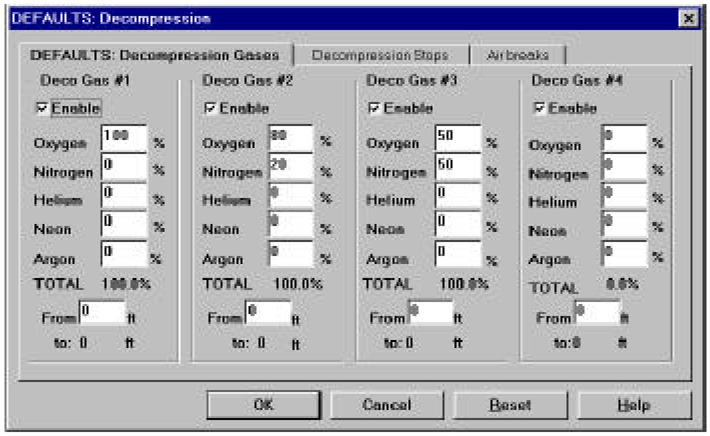
This section applies to All versions.

This allows you to specify whether or not Oxygen should be treated as a narcotic gas in the END calculations.

Tech Note:

100% per minute is the maximum rate that Abyss will allow the CNS Clock to tick at.

DEFAULTS--*Decompression*



The Defaults Decompression window is comprised of three main components, Deco Gases, Decompression Stops and Air Breaks.

Deco Gas tab

1. **Deco Gas:**

. Custom Mix allows you to create 4 specialty gases that you wish to use as a default decompression breathing gas, and to set the depth range over which this gas will be used automatically by Abyss during your ascent and decompression. Ranges may not overlap, however, if a deco gas is Disabled, the previous gas will confute in use through the disabled gas' range.

Once these defaults have been set, Abyss will automatically incorporate your desired decompression gas for you during your final ascent to the surface, and in all decompression calculations.

2. **Enable / Disable**

Allows you to selectively choose from your four deco gases. If you disable one gas, the gas to the right of it will be used to cover the disabled gas's depth range. I.e., the previous' gas' TO will update to match the next gas' FROM.

Deco Stops tab

3. **Deco Stops, *Decompression Stop Interval***:

This allows you to specify the incremental depths at which Abyss calculates your need for a decompression stop. Stops are available in 1, 2, 3, 4, and 5 meter intervals and 1, 5, 10, 15, and 20 foot intervals.

4. **Deco Stops, *Last Stop Depth***: A last stop option of 1/5/10/15/20 feet or 1/2/3/4/5/6 meters is also provided should the need arise for you to remain at a specific depth to complete your decompression.

5. **Deep Stops, *Enable / Disable*:**

Enables the default setting for adding additional Deep Stops to your normal decompression schedule. For detailed information on the concept of Deep Stops see the article "Deep Stops" in the Abyss appendix.

6. **Deep Stops, *First Deep Stop***

Allows you to choose the duration of the first deep stop. Choices are 1, 2 or 3 minutes.

7. **Deep Stops, *Other Deep Stops***

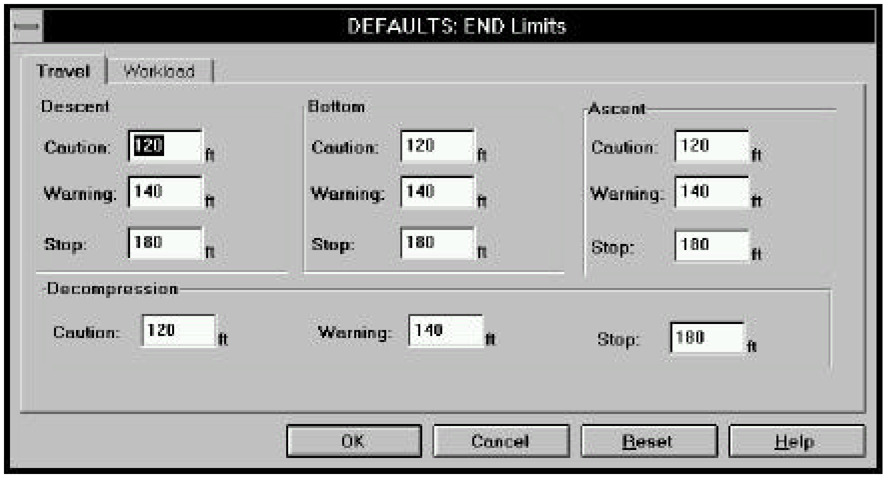
Allows you to choose the duration of all remaining deep stops. Choices are 1 or 2 minutes.

Air Breaks tab

8. **Air Breaks:**

When breathing 100% Oxygen it is generally held that a short period of breathing Air (an Air break) should be utilized to reduce the possibility of a CNS O2 hit. This field allows you to specify the number of minutes spent breathing 100% Oxygen before you wish to take an Air break, and then for what duration the Air break should be. You may also specify a Nitrox mixture other than Air to be used during your Air break.

DEFAULTS-Limits-*END*



This screen controls the automated alarms Abyss uses to inform you of your current exposure to Narcosis . This screen is divided into two main sections, each of which controls the Warning, Caution and Stop alarms that are displayed during the creation of your dive profile.

Your END is set in Feet or Meters..

Travel tab

1. **Descent:**
Allows you to set your END alarm values while descending..

2. **Bottom**:
Allows you to set your END alarm values while on the bottom, or for any waypoint where you are neither ascending or descending.

3. **Ascent**:
Allows you to set your END alarm values during your ascent.

4. **Decompression**:
Allows you to set your END alarm values during your decompression stops.

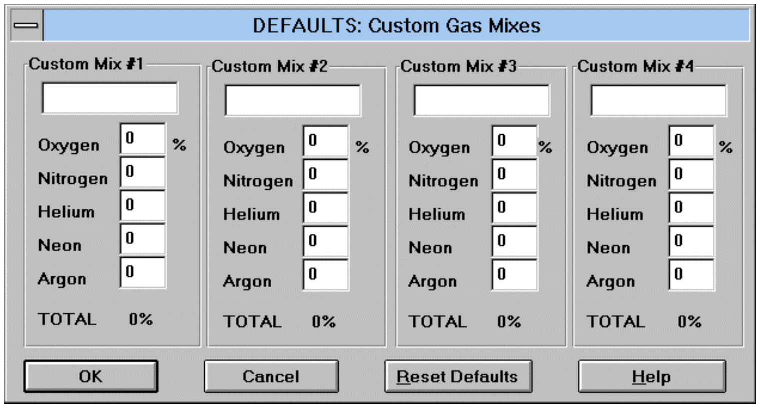
Workload tab

5. **Workload**:
Allows you to set your END alarm values according to various workloads/Depth combinations.

Tech Note:
Oxygen is about twice as lipid soluble as nitrogen, so it should theoretically be twice as narcotic. A very limited, controlled study suggests that oxygen is equipment to nitrogen, and that the reason is possibly that much oxygen is bound to Hb, and is metabolized in the tissues. The weakness of this assumption is that oxygen and nitrogen may not be equally narcotic across all ratios and at all depths.

Abyss uses the following relative narcotic values when computing your END unless you have selected Oxygen as Non-Narcotic in Defaults-CNS-exceptional:
Helium = 0, Neon = 0.28, Hydrogen = 0.55, Nitrogen = 1.00, Oxygen = 1.00, Argon = 2.33

DEFAULTS--Gas Mixes, *Custom*



Custom Gas Mixes allow you to specify the makeup and name of 4 custom breathing gases. Once these have been specified they will become available for you to use by selecting Custom from the Gas Mix box in any of the Abyss waypoint screens.

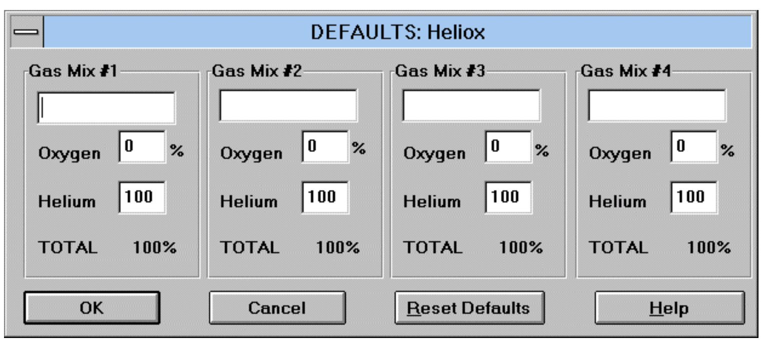
1. **Gas Mix Name**:

You are required to enter a name for your custom gas mix. This name will appear in the list box beside the Custom button on any of the waypoint screens.

2. **Gas Percentages**:

Enter the percentages of the various gases that constitute your custom mix..

DEFAULTS--*Gas Mixes, Heliox*



Helioxallows you to specify the makeup, and name of, 4 custom Heliox breathing gases. Once these have been specified they will become available for you to use by selecting Heliox from the Gas Mix box in any of the Abyss waypoint screens. The gases all start with 100% Helium and only require that you enter the correct amount of Oxygen for your desired mix.

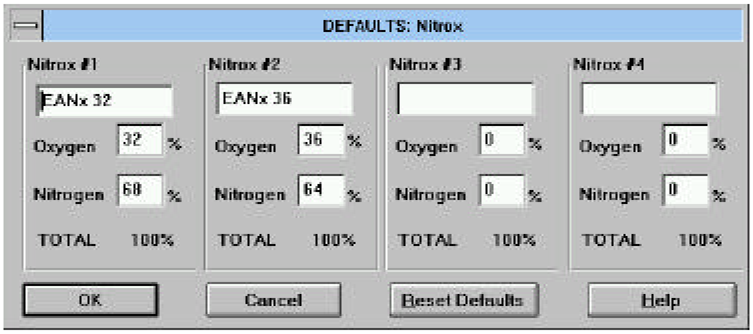
1. **Heliox Name:**

You are required to enter a name for your custom Heliox. This name will appear in the list box beside the Heliox button on any of the waypoint screens.

2. **Gas Percentages:**

Enter the percentage of Oxygen that your Heliox contains.

DEFAULTS--Gas Mixes, *Nitrox*



Nitrox allows you to specify the makeup, and name of, 4 custom Nitrox breathing gases. Once these have been specified they will become available for you to use by selecting Nitrox from the Gas Mix box in any of the Abyss waypoint screens. The gases all start with a 32% and a 36% Nitrox predefined.

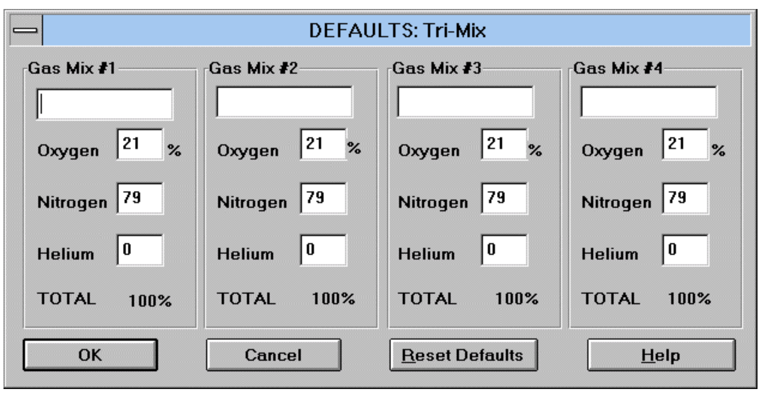
1. **Nitrox Name:**

You are required to enter a name for your custom Nitrox. This name will appear in the list box beside the Nitrox button on any of the waypoint screens.

2. **Gas Percentages:**

Enter the percentage of Oxygen and Nitrogen that your Nitrox contains.

DEFAULTS--Gas Mixes, *Trimix*



Trimix allows you to specify the makeup and name of 4 custom Trimix breathing gases. Once these have been specified they will become available for you to use by selecting Trimix from the Gas Mix box in any of the Abyss waypoint screens. All gases start out as Air. Any percentage entered in the Helium field will be automatically deducted from the Nitrogen percentage for your convenience.

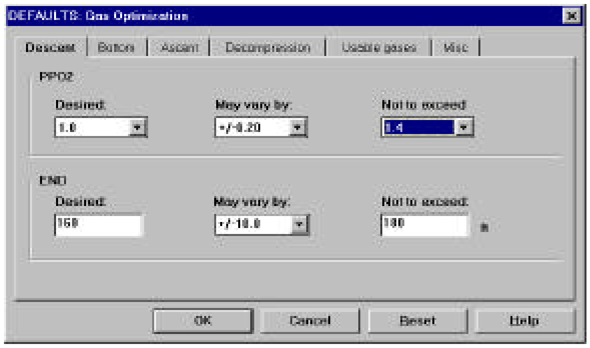
1. **Trimix Name:**

You are required to enter a name for your custom Trimix. This name will appear in the list box beside the Trimix button on any of the waypoint screens.

2. **Gas Percentages:**

Enter the percentages of Oxygen, Helium and Nitrogen that your Trimix contains.

DEFAULTS--*Gas Optimization (Rebreather & Open Circuit)*



The Gas Optimization screen allows you to define your PPO2 and END parameters that Abyss will use when calculating optimum gases, or a constant PPO2 (Rebreather style) for your dive. The Gas Optimization screen is broken into 5 major sections, Descent, Bottom, Ascent, Decompression and Usable Gases.. Examples for the Descent phase are provided.

1. **<u>Descent, PPO2 Minimum:</u>**
What is the minimum allowable PPO2 to be used during your descent?

2 **<u>Descent, PPO2 Desired:</u>**
Given a "perfect" breathing gas, what would your oxygen exposure (in ATM or BAR) be over the course of your descent? . The desired value for each phase is what Abyss will use to begin creating the "range" that the gas operates over.

3. **<u>Descent, PPO2 Not to Exceed:</u>**
What is the maximum PPO2 to which you are willing to be exposed?.

4. **<u>Descent, END Desired:</u>**
Given a "perfect" breathing gas, what would your narcosis exposure be over the course of your descent?

4. **<u>Descent, END Not to Exceed:</u>**
What is the maximum END to which you are willing to be exposed ?. This will control the Nitrogen/Helium percentages in the gas mix Abyss attempts to create if a Trimix is indicated.

5. **<u>Usable Gases for Computations:</u>**
Specify which gases Abyss is allowed to use when forecasting a possible gas mix.

The Gas Optimization feature in Abyss works by creating a series of gases that will work over particular depth ranges.
Exp. You have entered the following values for your Descent phase.
Min Ppo2 = 0.9, Desired = 1.0, Max = 1.1 and your first User Waypoint is set at 180feet.

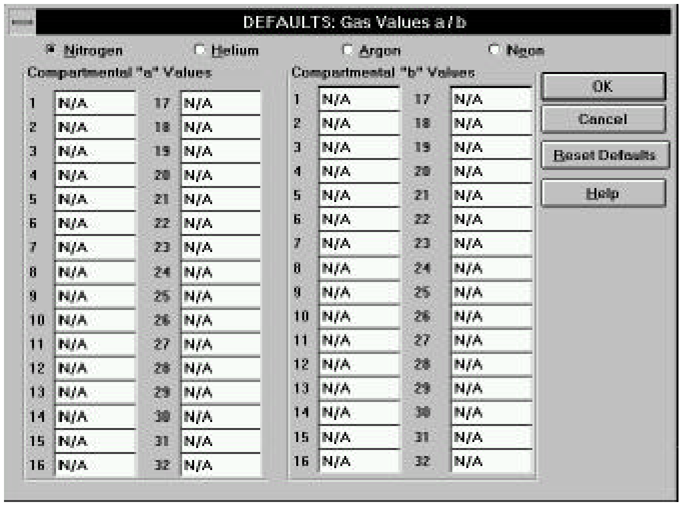
Abyss will first create a Best Gas for your current waypoint (0 ft) and evaluate whether or not that gas could be used at the next waypoint (180ft). Since there is no such gas Abyss will then begin lowering the initial PPO2 at the surface and making a series of trial descents attempting to get you from the surface to 180 feet with in your limits of 0.9 & 1.1 Eventually Abyss will determine that there is No gas that can make this transition. At that moment Abyss will insert a Gas Optimization Waypoint at the depth where either the Max PPO2 or the END is violated. This waypoint will indicate the maximum range of the first gas. Abyss will then begin again trying to find a gas that will get you from that waypoint to your User Waypoint. This process is repeated as many times as is needed until you arrive at 180 feet without violating either the Min or the Max Values. At the same time Abyss is comp uting the END values in the same manner. NOTE: The closer the Min and Max values are the greater the number of gases Abyss will create. For fewer gases allow Abyss a larger range between the Min and the Max PPO2, as well as the END.

Tech Note: ***Gas Optimization Phases are determined as follows***.
Bottom, any waypoint with a Time At > 3 minutes. DECO, any waypoint that is in mandatory Decompression.
Ascent, next depth is less than current depth AND it is not a Bottom or DECO point.

Descent, next depth is greater than current depth AND it is not a Bottom or DECO point.

Tech Note: Abyss will optimize each profile at least twice. To optimize a dive select Tools-Gas Optimization!!

DEFAULTS—Algorithm Controls, *A/B values:*



Abyss allows you direct access to the compartmental “A/B” values used in calculating your ongassing, offgassing and decompression. Though Abyss allows you access to these control values, we strongly recommend ***against*** changing them. Unless you are skilled in the art of Hyperbaric modeling, we suggest you use this information ***solely*** for reference purposes. Altering these values will fundamentally change how Abyss performs its Ongassing, Offgassing and Decompression computations. Roughly speaking, these values determine where the moving red bars on the tissue window are placed, and thus the amount of supersaturation that each tissue compartment can tolerate before requiring staged decompression. Abyss does not display its proprietary values on this screen.

1. **Nitrogen**:
   Use this button to display all of the a/b values for Nitrogen.

2. **Helium**:
   Use this button to display all of the a/b values for Helium.

3. **Argon**:
   Use this button to display all of the *experimental* a/b values for Argon.

4. **Neon**:
   Use this button to display all of the experimental a/b values for Neon.

Tech Note:

The Values used for NEON and ARGON should be considered EXPERIMENTAL only.

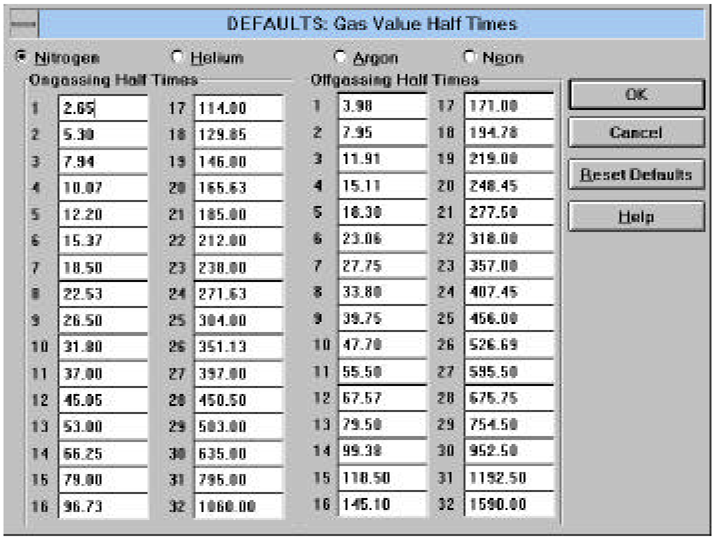
Very little hard data is available on the use of Neon and Argon in breathing gases, and Abyss deco schedules employing these gases ***must*** be considered ***Theoretical only.***

Special Warning:

If you do choose to employ the use of Neon be aware that recompression treatment for DCS involving

Neon is often <u>unsuccessful</u>. DCS involving Neon does not appear to respond well to standard recompression treatment.!!

DEFAULTS—Algorithm Controls, *Half-Times:*



	Ongassing		Ongassing		Offgassing		Offgassing
1	2.65	17	114.00	1	3.98	17	171.00
2	5.30	18	129.85	2	7.95	18	194.78
3	7.94	19	146.00	3	11.91	19	219.00
4	10.07	20	165.63	4	15.11	20	248.45
5	12.20	21	185.00	5	18.30	21	277.50
6	15.37	22	212.00	6	23.06	22	318.00
7	18.50	23	238.00	7	27.75	23	357.00
8	22.53	24	271.63	8	33.80	24	407.45
9	26.50	25	304.00	9	39.75	25	456.00
10	31.80	26	351.13	10	47.70	26	526.69
11	37.00	27	397.00	11	55.50	27	595.50
12	45.05	28	450.50	12	67.57	28	675.75
13	53.00	29	503.00	13	79.50	29	754.50
14	66.25	30	635.00	14	99.38	30	952.50
15	79.00	31	795.00	15	118.50	31	1192.50
16	96.73	32	1060.00	16	145.10	32	1590.00

Abyss allows you direct access to the compartmental half-times used in calculating your ongassing, offgassing and decompression. Compartments are some time referred to as "Tissues", as they may represent various tissue types in the body. This reference should not be taken literally, as there is no direct correlation between a specific tissue and a compartment in the model.

From here you can see the differences in the various algorithms that Abyss offers you.

1. <u>Ongassing half times:</u>
The theoretical number of minutes for a specific compartment to absorb 50% of its dissolved gas capacity.

2. <u>Offgassing half times:</u>
The theoretical number of minutes for a specific compartment to release 50% of its dissolved gas.

Tech Note:
The Values used for NEON and ARGON should be considered EXPERIMENTAL only.

Very little hard data is available on the use of Neon and Argon in breathing gases, and Abyss deco schedules employing these gases should be considered ***<u>Theoretical only</u>***.

Special Warning:

If you do employ the use of Neon be aware that recompression treatment for DCS involving Neon is often unsuccessful.

DCS involving Neon does not appear to respond well to standard recompression treatment.

DEFAULTS—Algorithm Controls *J-Factors*

One of the most advanced features of Abyss is the ability to modify many of the values that Abyss uses to calculate your decompression requirements. If after significant diving experience you have established your own ability to safely decompress, you may wish to modify these values, but under normal conditions these values should be left at the default settings.

Abysmal Diving Inc. ***STRONGLY advises you <u>NOT</u> to modify*** the “Oxygen Credit” or “Gas Adjustment” settings without first taking a proper course in hyperbaric physiology and decompression theory.

These values as a whole are often referred to as “J-Values”. They are made up of your Bottom Time, Depth, Oxygen Decompression Credit, and of an adjustment to the values of the individual breathing gases. Modifications to these values are displayed as percentages on the New Waypoint screen and on the Long Table print out. J-Factor modifications to your entered data are handled in the background by Abyss. All user entered data will “appear” to remain the same, even though Abyss is applying the requested modification to those values.

1. **<u>Bottom Time</u>**:

Allows you to modify your actual bottom time by a (+ or -) percentage.

Ex. Your actual bottom time is 60 minutes, but you have selected a +5% modifier, so Abyss calculates your decompression as though your bottom time were 63 minutes. The selection range is +5, 10, 15, 25, 50%, -5, 10, 15%

2. **<u>Depth</u>**:

Allows you to modify your actual depth by a (+ or -) percentage.

Ex. Your actual depth is 100ft, but you have selected a +10% modifier, so Abyss calculates your decompression as though your depth were at 110ft. The selection range is +5,+10,+15,+25,+50%, -5, 10, 15%

3. **<u>Oxygen Credit</u>**:

Allows you to modify the effectiveness of oxygen during decompression. The selection range is + or - 5, 10, 15, 25, 50%.

Ex. At 15ft you are breathing 100% oxygen, but you have selected an oxygen credit of -15%, so Abyss calculates your decompression as though the oxygen you are breathing is 15% less effective in removing other inert gases from your system.

4. **<u>Gas Adjustment</u>**:

Allows you to modify your actual percentage of breathed gas. This adjustment will only take effect if at least one of the gases you are breathing is left unmodified. If you modify all gases, there will be no way for Abyss to compensate. The selection range is + or - 5, 10, 15, 25, 50%.

Modification of these values will make the overall program more or less conservative as determined by Longer or Shorter decompression times.

Treat these settings with EXTREME care.
<u>Your life depends on it</u>.

DEFAULTS—Algorithm Controls *RGBM Parameters*

1) **BFTP** - *Bubble Film Tension Pressure*
This is the surface tension of the bubble when in a watery and/or fatty tissue. As the film strength increases the bubbles behave more like hard little "beebees" in the permeable region, and become tougher to dissolve under gas diffusion. Allowable measurements can range from 50 dynes/cm (in plasma) down to 11.5 dynes/cm (in fatty tissue).
This value should NOT be adjusted by the user without prior training in RGBM algo Theory.

2) **BSTP** - *Bubble Surfactant Tension Pressure*
This is the crumbling strength (the effective surface tension) of surfactant stabilized bubble.
Allowable measurement of force is from 215 dynes/cm to 280 dynes/cm.
This value should NOT be adjusted by the user without prior training in RGBM algo Theory.

3) **RTNBS** - *Relaxation Time for New Bubble Seed*s
This is the amount of time for bubble nuclei to regenerate during a dive. Not an important factor except for saturation exposures. Adaptation, measurements, observations, tests suggest that regeneration times vary between 2 days and 21 days.
Allowable durations are from 9000min (6.25 days) to 31,000min (21.5 days)
This value should NOT be adjusted by the user without prior training in RGBM algo Theory.

4) **FSBTTP** - *Film to Solid Bubble Tension Transition Pressure*
This is the crumbling surfactant pressure threshold, or where the bubble skins become impermeable to gas transfer. Yount and colleagues found a range from 4.5 atm up to 13.3 atm, Wienke assessed a range 8.5 atm up to 18 atm.
Allowable pressure ranges from 2.5atm to 12.5atm.
This value should NOT be adjusted by the user without prior training in RGBM algo Theory.

5) **NBMR** - *Nitrogen Bubble Mean Radius*
This is the mean excitation radius of a nitrogen bubble. As you increase the bubble size, more time is needed to shrink the bubble back down. Hence your deco times will increase and your NDL will decrease. Yount suggested .6 microns up t0 .95 microns. Wienke and others have measured .5 microns up tp 2.4 microns. Allowable user defined radius ranges are from 0.40 microns up to 1.60 microns. This value needs to be adjusted based upon the depth of the dive and is corrected with the buttons labeled "Shallow-Normal-Deep" on the defaults screen.

6) **HBMR** - *Helium Bubble Mean Radius*
This is the mean excitation radius of a helium bubble. As you increase the bubble size, more time is needed to shrink the bubble back down. Hence your deco times will increase and your NDL will decrease. Yount suggested .5 microns up to 1.3 microns. Wienke and others have measured .4 microns up to 2.2 microns. Allowable user defined radius ranges are from 0.40 microns up to 1.60 microns. This value needs to be adjusted based upon the depth of the dive and is corrected with the buttons labeled "Shallow-Normal-Deep" on the defaults screen.

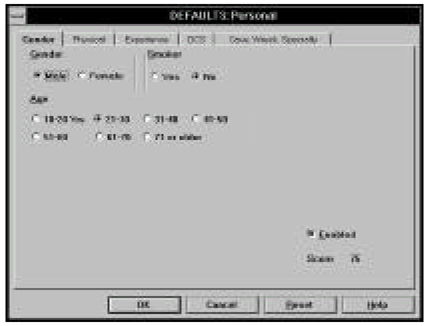
7) **EBV** - *Excited Bubble Volume*
The energy per separated permissible phase growth rate. As you decrease the phase volume the decompression constrainst become more stringent and NDLs are shortened. Critical fits by Yount, Wienke and from statistical mechanics suggest a range 8550 fsw min down to 4550 fsw-min. Allowable user defined radius ranges are from 5000fsw to 8000fsw.
This value needs to be adjusted based upon the depth of the dive and is corrected with the buttons labeled "Shallow-Normal-Deep" on the defaults screen.

8) **CLAM** -- free energy per unit bubble volume growth rate. Nominal value is 556 fsw min. Critical fits by Yount, Wienke, and statistical mechanics suggest range 641 fsw min, down to 342 fsw min. In 200 fsw range, value is near 530 fsw min, while for shallow dives, value is 600 fs min.

Modification of these values will make the overall program more or less conservative as determined by Longer or Shorter decompression times.

Treat these settings with EXTREME care.
Your life depends on it.

DEFAULTS—Physiology-*Personal*



The Personal Defaults screen allows you to describe yourself in a generalized format to Abyss. This information is used in altering the base equations of the decompression models in Abyss. The score on this page is used to fine tune the Abyss decompression model, rather than to make gross changes to it. Should you decide not to use this feature, simple deselect the Enable button on the bottom right of the screen.

1. **Gender:**
Are you male or female?

2. **Smoker:**
Are you a regular smoker?

3. **Age:**
What is your age group?

4. **Physical Condition:**
What is your general overall physical condition in your personal opinion?

5. **Body Fat:**
What is your weight relative to your height?

6. **Years Diving:**
How many years have you been actively diving?

7. **Skill Level:**
What educational/experience level are you at in your diving?

8. **DCS:**
Have you ever had a DCS hit, if so, how many times?

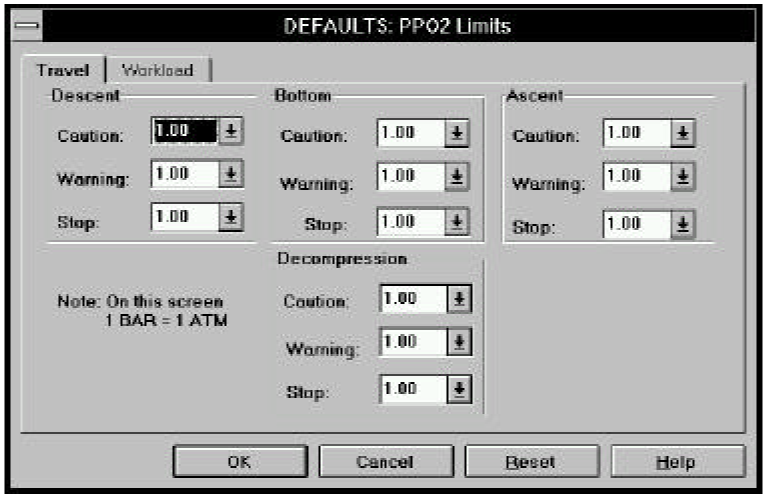
9. **Cave:**
Are you Cave trained, if so, to what degree?

10. **Wreck:**
Are you Wreck trained, if so, to what degree?

11. **Technical:**
Have you taken a specialty technical Dive training?

12. **Score:**
At the bottom right of the screen is a score. This number will vary from 0-100. It represents your relative level of diver fitness, 100 being totally fit (best condition of Body & Skills), 0 being totally unfit.

DEFAULTS—Limits-*PPO2*



This screen controls the automated alarms Abyss uses to inform you of your current exposure to Oxygen. This screen is divided into five separate sections, each of which controls the Warning, Caution, Stop and your workload limits alarms that are displayed during the creation of your dive profile.

1. **Descent**:
   Allows you to set, in Partial Pressure of ATMs or BAR, the alarm values while descending.

2. **Bottom**:
   Allows you to set, in Partial Pressure of ATMs or BAR, the alarm values while on the bottom, or for any waypoint where you are neither ascending or descending.

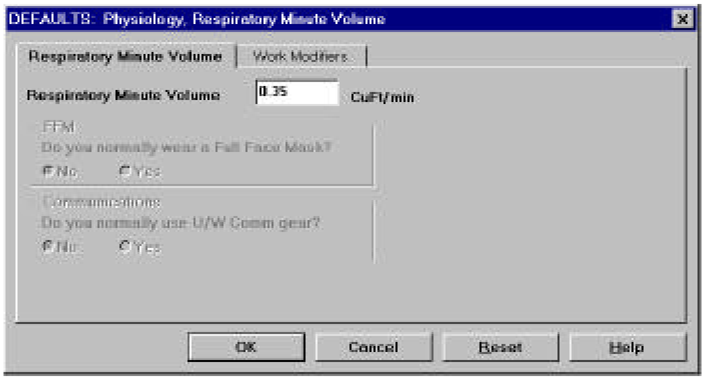
3. **Ascent**:
   Allows you to set, in Partial Pressure of ATMs or BAR, the alarm values during your ascent.

4. **Decompression:**
   Allows you to set, in Partial Pressure of ATMs or BAR, the alarm values during your decompression stops.

5. **Workload:**
   Allows you to set, in Partial Pressure of ATMs or BAR, the alarm values during the various types of workloads to which you may be exposed.

Ex. While on the bottom at a depth of 100 feet your PPO2 is 1.35 and workload is Mild. If you had set your alarm values for bottom at Caution 1.4, Warning 1.45, Stop 1.5 you would have not received a alarm for general PPO2 exposure, but if your workload limits had been set to Resting 1.4, Mild 1.35, Moderate 1.3, Heavy 1.2, Extreme 1.1 then you would have received a Workload Alarm for exceeding your maximum PPO2 exposure while working.

DEFAULTS—Physiology *RMV*



The Respiratory Minute Volume screen is made up of two primary components, your RMV and your Workload Modifiers.

1. **<u>Respiratory Minute Volume</u>**:
This is your known and measured breathing rate, (while at rest & on the surface), expressed in either Cubic Feet per minute or Liters per minute.

Note: *Your RMV is **NOT** your **SAC** rate!*

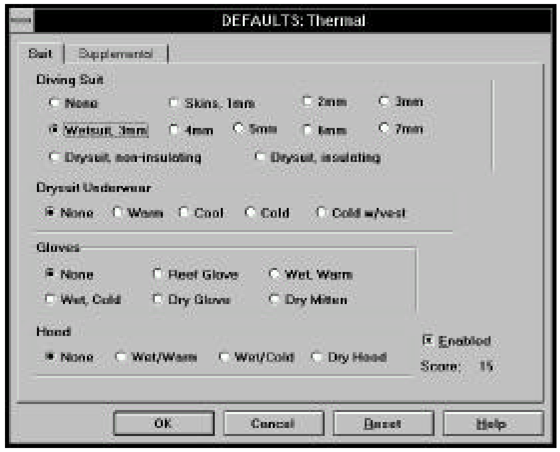
2. **<u>Full Face Mask:</u>**
Do you regularly wear a full face mask as opposed to a Bite-On regulator? This information is used in computing your anticipated gas consumption.

3. **<u>Underwater Communications:</u>**
Do you regularly use an underwater communications device, either with a full face mask or without. This information is used in computing your anticipated gas consumption.

4. **<u>Workload Modifier</u>**:
Allows you to "Fine Tune" your individual breathing patterns into ABYSS' gas consumption calculations. The Workload Modifier takes your RMV and multiplies it by the attached factor to compensate for increased breathing from increased work. By selecting a percentage modification to each of the different settings, you can more accurately reproduce your actual breathing volumes. Ranges are plus 10, 25, 50, 75, 100, 125, 150, 175 or 200%, and minus 10, 25, 50 or 75%.

Rest/Normal, *finning with little effort, or hanging on decompression.*
Mild, *finning with some effort, more "active" diving.*
Moderate, *finning against a current, some exertion.*
Heavy, *finning hard, working while diving.*
Extreme, *finning as hard as you can, heavy breathing.*

DEFAULTS—Physiological-*Thermal*



The Thermal Defaults allow you to give Abyss a detailed description of the thermal protection that you will be using on your dive, as well as offer some basic information about how you cool when in water. This information will be used in modifying the basic decompression equations in Abyss. . The score on this page is used to fine tune the Abyss decompression model, not to make gross changes to it. Should you decide you don't desire to use this feature, simply deselect the Enable button on the bottom right corner of the screen.

1. **Diving Suit:**
   In general, which of these best describes the diving suit you normally wear.

2. **Drysuit Underwear:**
   If you use a drysuit, which of these best describes the insulation you normally wear.

3. **Gloves:**
   What type of glove do you wear?.

4. **Hood:**
   What type of hood do you wear?.

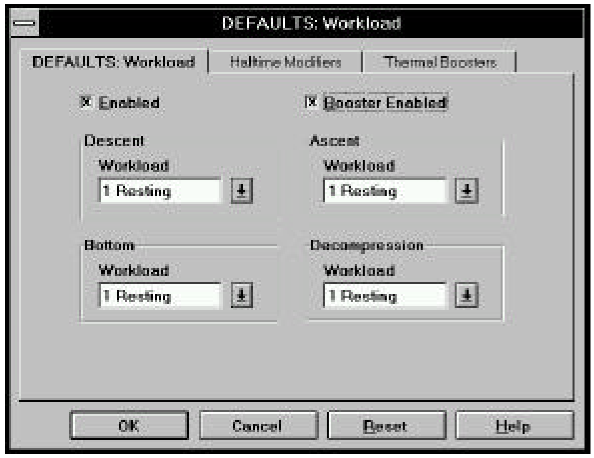
5. **Supplemental:**
   If you use any supplemental source of heat or insulation, what kind is it?
   More than one answer may be selected for this field.

6. **Cooling:**
   Relative to other divers, how rapidly do you get cold while in the water?

7. **Default Water Temp:**
   What is the water temperature that you want Abyss to use as a default on the New Waypoint screens?

8. **Score:**
   At the bottom right of the screen is a score. This number will vary from 0-100. It represents your relative level of thermal insulation. 100 being totally insulated (for all practical purposes), 0 being bare skinned in the water.

DEFAULTS—Physiological-*Work Load*



The Workload Defaults allow you to specify your normal level of activity during the four various phases of your dive.

Rest, *finning with little effort, or hanging on decompression.*
Mild, *finning with some effort, more "active" diving.*
Moderate, *finning against a current, some exertion.*
Heavy, *finning hard, working while diving.*
Very Heavy, *finning very hard, working hard while diving.*
Extreme, *finning as hard as you can, maximum breathing*

1. **Descent:**
What is you normal level of exertion to get to the bottom?

2. **Bottom:**
What is your normal level of exertion during the working phase of your dive?

3. **Ascent:**
What is your normal level of exertion during your ascent?

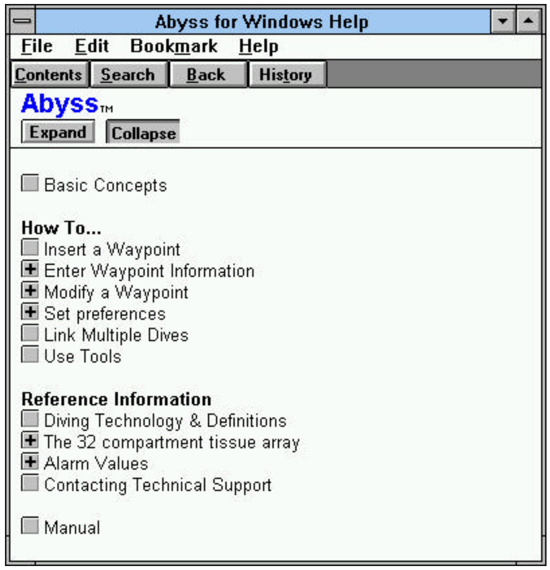
4. **Decompression:**
What is your normal level of exertion during decompression?

5. **Thermal Booster:**
Based upon your workload Abyss will add this number of degrees to the water temperature to compensate for the additional thermal energy you are generating from your work. This increase will effect the decompression model.

6. **Halftime Modifier:**
Based upon your workload, Abyss will alter ALL compartmental halftimes to account for changes in the rate of ongassing and offgassing as a result of your increased workload.

Workload	***Thermal Booster***	***Half-time Modifiers***	
		Ongassing	Offgassing
Resting	+0	HT = 100% of original value	HT = 100% of original value
Mild	+2F / 1.1C	HT = 100% of original value	HT = 95% of original value
Moderate	+5F / 2.86C	HT = 90% of original value	HT = 110% of original value
Heavy	+15F / 8.3C	HT = 75% of original value	HT = 125% of original value
Very Heavy	+20F / 11.1C	HT = 62% of original value	HT = 138% of original value
Extreme	+25F / 13.8C	HT = 50% of original value	HT = 150% of original value

HELP--*Using Abyss help*



The Abyss help system is composed of three primary sections designed to make using Abyss as easy as possible.

1. **Screen Help Button**:
Every screen in Abyss has a Help Button. By pressing this button the corresponding page of the Abyss manual will be displayed to assist you with any difficulties.

2. **Electronic Manual**:
The entire contents of the printed Abyss manual are available to you on-line as an electronic book. This is provided to you in the same format as the manual itself for easy access.

3. **Diving Technology and Definitions**:
This section of the help system provides you with definitions of hundreds of hyperbaric and medical terms and in-depth descriptions of important diving concepts.

LOGBOOKS--*Overview*

1. Basic Operations.

The concept behind these logs is the use of multiple separate "Pages". Each of these pages are dedicated to a specific part of the log. The "Dive Log" page is the master page that links all of the others together and forms the front end of the logbook itself. This allows you to use the same page again and again without ever having to re-enter the data.

> Exp. You have three dive buddies that you regularly dive with. You enter all of the information for these three buddies into the Buddy Log as three separate table entries. On the Dive Log page (Master page of the divelogs) you can now select one of these three buddies anytime you want with-out having to re-enter any of his information. You can select these pages in one of two ways.

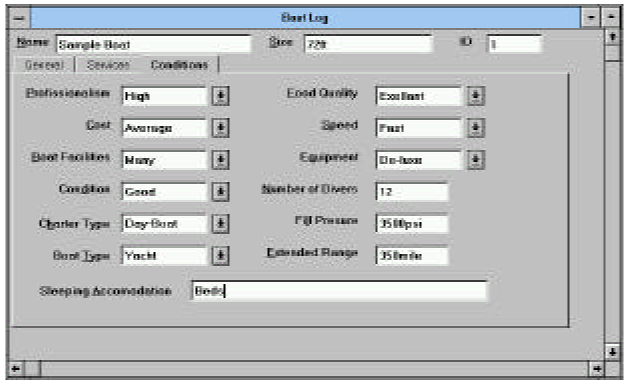
2. Creating a new Record.

On the right hand side of the Dive Buddy entry line on the Master page are two buttons. One marked "B" and the other marked "Buddy". Clicking on the "B" will bring up a listing of all the entries in the buddy log, to select a buddy and enter it on the Dive Log simply double click on it. Clicking on the "Buddy" will open the Buddy Log itself and allow you to edit its contents. These functions work the same for all of the logs.

To create a New entry in any of the logs, simply open the desired log (by selecting it from the menu bar Logs-xxx, or by clicking on its button) and then press the New Record Icon (11th icon from the left) or by selecting Record-New from the menu bar. This will give you a clean blank record waiting for you to fill in all of the details. When you are done editing it, simply close the table, add another record, or press Record-Save and it will be saved automatically.

All "ID" fields are filled in automatically by Abyss, and are sequential starting at 1.

LOGBOOKS--*Boat Log*



The Boat Log is designed to allow you to keep a record of each different dive boat you have been on.

1. **Boat Name**, enter the new name of the boat or select the name of a previous boat you have dove on from the drop down window.

2. **Size**, what is the length of the boat?

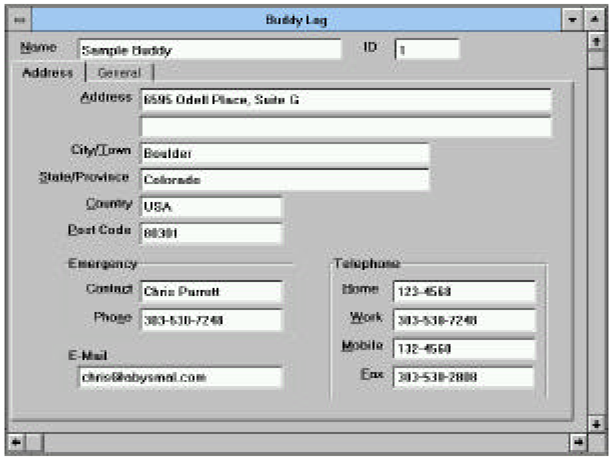
3. **ID**, Boat Log page entry number, this identifies this entry from all others, including other pages about the same boat.

1. *General:*
   Boat Captain, enter the new name of the captain, or select the name of a captain of a previous dive you have been on from the drop down window.
   Docks At, enter the new port or dock that the boat normally operates out of or select a port/dock that you have previously entered from the drop down window.
   Destinations, enter a list of dive sites the boat commonly goes to.
   General Comments, enter your overall feelings & general thoughts about this dive boat.

2. *Services:*
   Yes/No check boxes, did the boat have any of these facilities available to you?

3. *Conditions:*
   Professionalism, did the crew know what they were doing, were they skilled?
   Cost, where was the cost as compared to other dive boats?
   Boat Facilities, how many facilities did the boat offer you as a diver?
   General Condition, what was the overall upkeep of the boat?
   Charter Type, is this boat for single day (overnight) or multi-day trips?
   Boat Type, what kind of a vessel is this?
   Equipment, what is the quality of the boats equipment?
   Speed, what is the general speed this vessel travels at?
   Food Quality, what was the overall quality of food?
   Number of divers, how many people does this boat carry?
   Fill Pressure, what is the maximum fill pressure offered onboard?
   Extended, what is the maximum range this boat travels?
   Sleeping Accommodations, what bunking is available?

LOGBOOKS--*Buddy Log*



The Buddy Log is designed to allow you to keep a record of all of your dive partners and contains general information fields to help you accomplish that.

1. **Name**.
   Enter your dive buddy's full name.

2. **ID**, Buddy Log page entry number, this identifies this entry from all others, including other pages about the same buddy.

Address Tab:

Address. Enter your dive buddy's home street address.

City. Enter your dive buddy's home town or city.

Province. Enter your dive buddy's state or province of residence.

Country. Enter your dive buddy's country of residence.

Postal Code. Enter your dive buddy's zip or postal code.

Emergency Contact. Enter the name of the person to contact in the event of an emergency.

Emergency Phone #. Enter the phone number to be called in the event of an emergency.

Work Phone #. Enter your dive buddy's daytime phone number.

Home Phone #. Enter your dive buddy's evening phone number.

Mobile/Cellular #. Enter your dive buddy's mobile or cellular phone number.

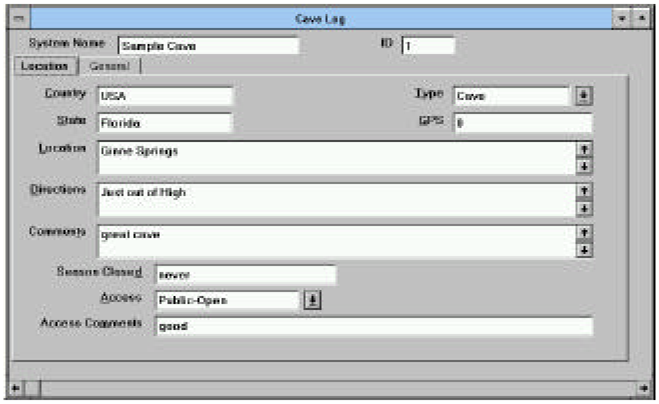
E-Mail. Enter your dive buddy's e-mail account number.

General Tab:

Certification. Enter you dive buddy's training agency and level of certification.

General Information. Enter any additional information you want to keep track of.

LOGBOOKS--*Cave Log*



1. **<u>System Name</u>**, What is the common name of this cave system, or this specific section?

2. **<u>ID</u>**, Cave Log page entry number, this identifies this entry from all others, including other pages about the same cave.

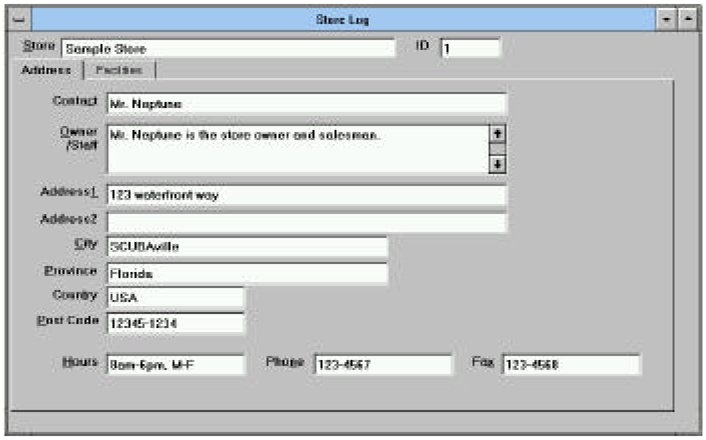
Location

<u>Country</u>, What country is this cave located in?
<u>State</u>, What state or province is it in?
<u>Location</u>, What is the specific location of the cave system?
<u>Directions</u>, In general, how do you get to this cave?
<u>Type</u>, What kind of a cave is it?
<u>GPS</u>, What are the exact Global Positioning System coordinates?
<u>Comments</u>, General commentary on the cave.
<u>Season Closed</u>, If this cave is seasonally closed or regularly undiveable, when are those closures
<u>Access</u>, What restrictions are placed on access?
<u>Access Comments</u>, General comments on access problems or concerns.

General

<u>Max Known Penetration</u>, What is the maximum known horizontal penetration?
<u>Penetration</u>, What was your penetration?
<u>Avg. Vis</u>, What is the average visibility?
<u>Avg. Temp</u>, What is the average temperature?
<u>Water</u>, What is the water type in this cave system?
<u>Max known Depth</u>, What is the maximum known vertical depth?
<u>Max Depth</u>, What was your depth?
<u>Entrance Depth</u>, What is the depth of the main entrance to the system?
<u>Flow Direction</u>, Is this a Spring, siphon etc..?
<u>Flow Rate</u>, In general, what is the water volume moving in this system if any?
<u>Route Taken</u>, General comments on your route.
<u>Jumps</u>, Any jumps that you made.
<u>Dry Gear Needed</u>, What dry cave gear, if any, was required to make this dive?
<u>Best Diving</u>, When & Where is the best diving in this cave?

LOGBOOKS--*Dive Centers*



The Dive Center Log is designed to allow you to keep a permanent record of all dive centers and dive resorts you use or visit. It contains several general information fields to help you record that information.

1. **Store**. What is the name of the dive store or dive centre?

2. **ID**, Dive Center Log page entry number, this identifies this entry from all others, including others about the same store.

Address

Contact. Who do you normally do business with?

Owner/Staff. Who is the owner or who is your primary contact?

Address 1 & 2. What is the street address?

City. What city is it located in?

State/Province. What state or province is this shop located in?

Country. What country is it in?

Postal Code. What is the Zip or Postal code?

Hours. What hours is this facility open for business?

Phone Number. What is the business phone number including any area codes.

Fax Number. What is the business fax number including any area codes

Facilities

Boat Charters.

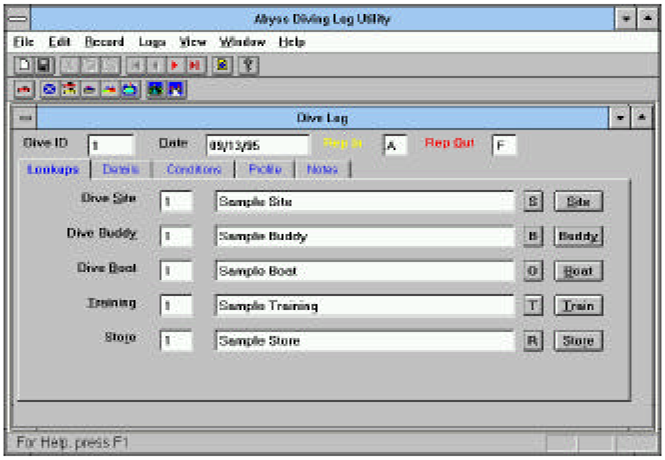
Fill Pressure. What is the maximum fill pressure this store offers?

Notes. General notes about this facility.

Boat 1, 2, 3, 4. Boats that offer charters from this store. These are links to the Boat Log.

General Information. Any general information you want to keep track of.

LOGBOOKS--*Dive Log*



The Dive Log is the master log screen that allows you access to all of the other logbook entries. From this screen you can move to the Site, Boat, Gear, Buddy, & Dive Center logs. It also contains basic summary information about the dive.

1. **Dive ID**, This is your Dive Log page number.

2. **Date**, The date you made your dive.

3. **Rep In**, Your repetitive group upon entering the water.

4. **Rep Out**, Your repetitive group upon exiting the water.

Lookups

Boat, Buddy, Site, Store, Training Buttons, These are the master page link controls, that allow you to open to each of the other Log Book pages.
S, B, O, T, R, are the lookup buttons that allow you to see the record contents of each of the linked tables. By clicking on them you can quickly scan and select an individual record for linking.

Details

Time In, the time you began your dive.
Time Out, the time you exited the water, and ended your dive.
Bottom Time, the time you consider yourself to have spent on the bottom.

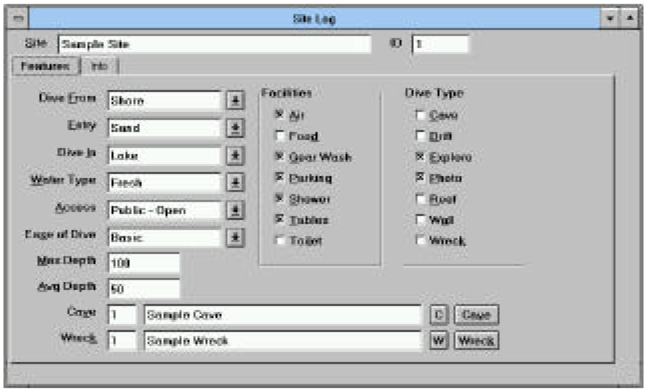
Tech Note*: This is not a time that Abyss tracks in the dive planner as there are multiple definitions of what bottom time is supposed to be. Abyss tracks the actual time spent at every depth.*

Deco Time, the total amount of time you spent in decompression.
Start & Ending Pressure, the pressure reading your SCUBA cylinder began with at the beginning of the dive and ended with at the completion of the dive.
Water Temperature, the measured temperature of the water on the surface and at your average depth.
Visibility, the distance that you could see on the surface and at your average depth.

Conditions

Day / Night, Was it a day dive or a night dive?
Currents, What were the currents you encountered?
Seas, Were there any rough seas, and if so how strong?
Surge, Was there any surge, and if so how strong?
Weather, How was the weather?

LOGBOOKS--*Site Log*



The Dive Site Log is provided to you to record the basic information about the location of your dive. It consists of a series of yes/no check boxes and multiple choices where you indicate which description best fits your dive.

1. **Site**, The common name of the dive site you visited.

2. **ID**, Dive Site Log page entry number, this identifies this entry from all others, including others about the same site.

Features

Dive From, what did you enter the water from?

Entry, if a shore dive, what did you have to cross to enter the water?

Dive In, what body of water were you diving in?

Water Type, was this a sea water or a fresh water dive?

Access, What restrictions to access are there to this dive site?

Ease of Dive, how would you rate the overall level of difficulty?

Max / Average Depth, what is the average and maximum depths at this site?

Facilities, what facilities did you find available?

Dive Type, what was the purpose of this dive, you may select more than one answer.

Cave, if there was a cave at this site, you can establish a link to the Cave Log.

Wreck, if there was a wreck at this site, you can establish a link to the Wreck Log

Info

Country, what country does this dive site fall into?

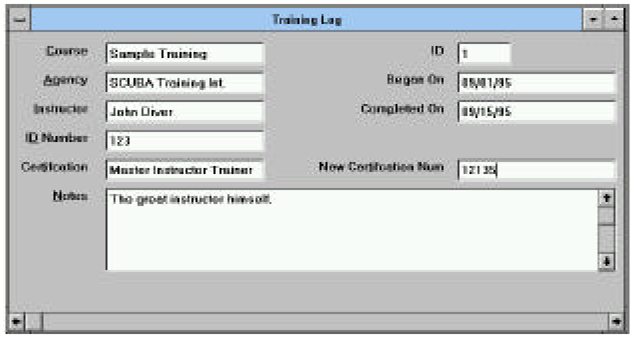
Province, what state within that country is the dive site located in?

City/Town, what is the closest City or Town to the dive site?

Directions, How do you get to this location?

General Info, your personal comments about this dive site.

LOGBOOKS--*Training Log*



The Dive Training Log provides you with a means to record any classes you have taken as a student.

1. **ID**, Dive Site Log page entry number, this identifies this entry from all others, including others about the same site.

2. **Course.**
What was the title of the course?

3. **Agency.**
What was the certifying agency that sanctioned the course?

4. **Instructor**.
Who was the instructor for the course?

5. **ID Number**.
What is the instructor's ID number?

6. **Certification**.
What is the level of certification of the course instructor?

7. **ID**.
Training Log page entry number, this identifies this entry from all others, including others about the same course.

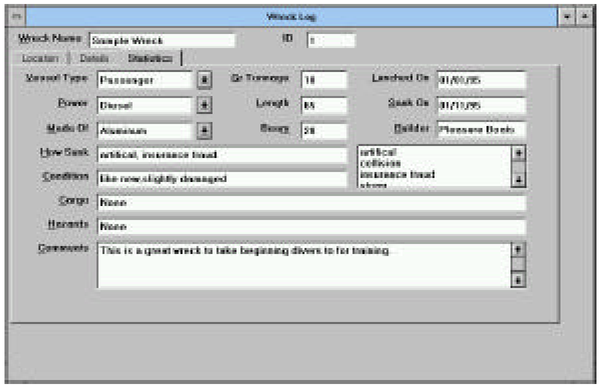
8. **Began on.**
Date this course started.

9. **Completed On.**
Date this course finished on.

10. **New Cert #.**
What is your new certification number from completing this course?

11. **Notes**.
What general thoughts do you have about this course?

LOGBOOKS--*Wreck Log*



1. Wreck Name, what is the common name of this shipwreck
2. **ID**, Wreck Log page entry number, this identifies this entry from all others, including others about the same wreck.

Location

Country, In the waters of which country does it lay?
State/Province, which state or province is it in?
Location, What is the location in general terms?
Ocean / Lake, Which Ocean or lake does it lay in?
Lat. / Long , What is the Latitude and Longitude of the wreck?
Chart #, Which chart is used to locate this wreck?
GPS, What are the Global Positioning Satellite co-ordinates?
Directions, How would you find this wreck if looking for it?

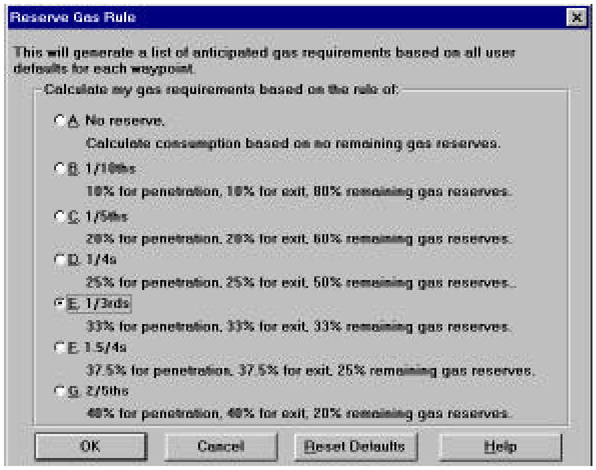
Details

Difficulty, Rate the general level of difficulty of diving on this wreck.
Thermoclines, At what depth/s did you encounter a thermocline?
Avg. Vis, What was the average visibility for the entire wreck?
Bottom, What is the bottom made up of?
Aquatic Growth, What percent of the wreck is covered in growth?
Currents, Where there any currents on this wreck?
Status, Is this a protected wreck?
Depths, List the depths of the major landmarks on the wreck.
Artifact recovery, is artifact recovery allowed?
Penetrable, can the wreck be penetrated?
Penetration comments, basic info about penetrating the wreck?

Statistics

Vessel Type, what kind of a vessel was this?
Power, What was its primary source of power?
Made Of, What was it constructed of?
Gross Tonnage, What was its gross tonnage of the ship?
Length, Overall length of the ship?
Beam, What was its Beam?
Lunched On, When was it first launched?
Sank On, On what date did it sink?
Builder, Who constructed this vessel?
How Sunk, How was the ship sunk?
Condition, What is the current condition of the remains of the wreck?
Cargo, What was the cargo when the ship sank, and what is onboard now?
Hazards, What special hazards are associated with diving this wreck?
Comments, General comments about this shipwreck?

Deco Tables—Short & Long "*gas reserves*"



The Deco Tables, Gas Reserves screen allows you to request Abyss to perform a review of your dive profile and estimate what your likely gas volume requirements will be. This information is based upon a variety of the default screens (Ascent/Descent, Decompression, J-Factor, Personal, RMV, Thermal, Workload) and the information you supply at each of the dive waypoints.

1. **Total Gas Consumed**:
   Abyss will predict the total volume of gas you will breath on this dive in CuFt or Liters.

2. **Total Gas Consumed by individual gas**:
   Abyss will predict the total volume of each of your individual breathing gases.

3. **Rule:**
   This allows you to specify a gas consumption/reserve rule.
   A. **No reserve**.
      Calculate consumption based on no remaining gas reserves.

   B. **1/10ths**. 10% for penetration, 10% for exit, ***80%** remaining gas reserves*.

   C. **1/5ths**. 20% for penetration, 20% for exit, ***60%** remaining gas reserves*.

   D. **1/4s**. 25% for penetration, 25% for exit, ***50%** remaining gas reserves*..

   E. **1/3s**. 33% for penetration, 33% for exit, ***33%** remaining gas reserves*..

   F. **1.5/4s**. 37.5% for penetration, 37.5% for exit, ***25%** remaining gas reserves*..

   G. **1/2s**. 40% for penetration, 40% for exit, ***20%** remaining gas reserves*..

Deco Tables—Short

ABYSS-98, Advanced Dive Planning Software

This ***Short*** table printed for: ***Chris Parrett on June 16, 1998***

Profile: *Abyss1* **Template**: *Default*

ATTENTION: *The fact that this table was generated by ABYSS does not guarantee freedom from the possibility of decompression sickness. Diving is an inherently dangerous activity that may result in injury or death. Following this Abyss diving profile does not assure me that I won't be injured or killed. Decompression, Deep Diving, Cave & Wreck Penetration and the use of Mixed Gas while diving are extremely hazardous aspects of an already dangerous activity.*

Surface Altitude **0 ft,** Safety Altitude, **1,770ft** Algorithm, **Abyss 150**

J-Factors: **Depth** = **+0%**, **Bottom Time** = **+0%**, **N2** = **+0%**, **He** = **+0%**, **Ne** = **+0%**, **Ar** = **+0%**

Depth (ft)	Time at	Run Time	Gas & Percent O2%	N2%	He%	Status
0	0.	0.0	21	79	0	Surface
50	**5**	5.3	21	79	0	**Entered by user**
60	0	5.6	21	79	0	Default rate change
120	0	6.1	21	79	0	Default rate change
180	0	6.7	21	79	0	Default rate change
240	0	7.5	21	79	0	Default rate change
250	**5**	12.7	21	79	0	**Entered by user**
250	0	12.7	21	79	0	Default rate change
180	0	13.1	21	79	0	Default rate change
90	0	14.0	21	79	0	Default rate change
60	0	14.5	21	79	0	Default rate change
31	0	15.3	50	50	0	Default ***decompression gas change***
30	**2**	17.3	50	50	0	**DECO**
21	0	17.5	80	20	0	Default ***decompression gas change***
20	0	17.5	80	20	0	Default rate change
20	**3**	20.5	80	20	0	**DECO**
11	0	21.0	100	0	0	Default ***decompression gas change***
10	**4**	25.0	100	0	0	**DECO**
0	0	25.7	21	79	0	Surface

DECO Stops.

Depth (ft)	Time at	Run time	Gas & Percent O2%	N2%	He%	Status
30	2	17.3	50	50	0	DECO
20	3	20.5	80	20	0	DECO
10	4	25.0	100			DECO

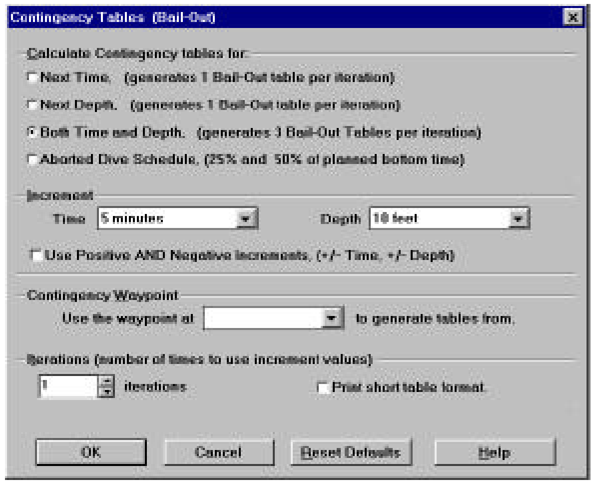
DIVE SUMMARY

Run Time	26 Minutes	*Deco Time*	9Min
CNS Clock	31.88%	*OTUs*	30.16
Max PPO2	**1.80** (Atm)	*Min PPO*	0.21(Atm)
Max END	250.00 (ft)	*Max Workload*	Mild
RMV	0.35 (CuFt/M)	*Max Depth*	250.00 (ft)

Gas Consumption

Gas & Percent O2%	N2%	He%	Volume *(CuFt)*					
21	79	0	38.5+	19.2	Reserves	Total Gas Consumed		44.09
50	50	0	1.5+	0.7	Reserves	Required reserve	***Thirds***	
80	20	0	1.9+	0.9	Reserves	Total Reserves		22.05
100			2.0+	1.0	Reserves	**Total Gas Required**		**66.14 (CuFt)**
			44.0+	**22.0**				

Deco Tables—*Bail-Out & Contingency Tables*



The Bail-Out screen allow you to specify in what manner you would like your contingency tables to be generated.

1. **<u>Calculate Contingency Tables for</u>**:

A. **For the next greater time exposure.**

Creates a series of tables based upon the time increment you specify.
Exp. Dive is to 100ft for 100 minutes, Increment is 10 minutes, Iteration is 3.
Abyss will create a series of tables for 100ft / 10 min , 100ft / 20 min, 100ft / 30 min

B. **For the next greater depth exposure**.

Creates a series of tables based upon the depth increment you specify.
Exp. Dive is to 100ft for 100 minutes, Increment is 10 feet, Iteration is 3.
Abyss will create a series of tables for 100ft / 10 min , 110ft / 10 min, 120ft / 10 min

C. **For both the next greater depth and time**.

Creates a Full series of tables based upon the time & depth increment you specify.
Exp. Dive is to 100ft for 100 minutes, Increment is 10 feet & 10 minutes, Iteration is 3.
Abyss will create a series of tables for
100feet / 10 min, 100ft / 20 min, 100ft / 30 min
110feet / 10 min, 110ft / 20 min, 110ft / 30 min
120feet / 10 min, 120ft / 20 min, 120ft / 30 min

D. **For Aborted Dive Schedule.**

Creates a series of tables based upon a 25% & 50% fraction of your bottom time.
Exp. Dive is to 100ft for 100 minutes.
Abyss will create a series of tables for 100ft / 25 min , 100ft / 50 min

2. **<u>Time Increment</u>**:
Instructs Abyss as to the number of minutes for each table variation.

3. **<u>Depth Increment</u>:**
Instructs Abyss as to the number of units of depth for each table variation.

4. **<u>Use Positive AND Negative Increments:</u>**

Instructs Abyss to calculate both the positive (+Depth) and (+Time) tables, as well as the Negative (-Depth) and (-Time

5. **Contingency Waypoint.**
Instructs Abyss from which waypoint to make the time/depth modifications in order to generate the Bail-Out tables.

6. **Iterations**.
The number of times to use the Time or Depth increment.

Depth (fsw)	Btm Run Time	Total Deco	AIR 100	AIR 90	AIR 80	AIR 70	AIR 60	EAN 50 50	EAN 50 40	EAN 50 30	EAN 80 20	100% O2 10	Total Run Time	CNS
180	12	11								2	3	6	25	
	22	33						2	4	4	7	16	57	
	32	57					3	4	6	7	13	24	92	
	42	84				3	4	6	8	11	17	35	128	
	52	103			1	4	7	8	11	14	23	46	157	
190	12	13							1	2	3	7	27	
	22	37					1	3	3	5	8	17	61	
	32	65				2	3	4	7	8	14	27	99	
	42	95			1	4	5	6	10	12	19	38	139	
	52	128			3	5	8	8	13	15	25	51	182	102
200	12	16							2	2	4	8	30	
	22	42					2	3	4	5	9	19	66	
	32<<	72			1	2	4	5	7	9	15	29	106	
	42	107			3	4	6	7	11	13	21	42	151	
	52	132		2	3	6	9	9	14	17	27	56	186	113
210	12	18						1	2	2	4	9	32	
	22	44				1	3	3	4	6	10	20	68	
	32	80			2	3	4	6	8	10	16	31	114	
	42	118		1	4	4	7	8	11	14	23	46	162	
O2 TOX!!	52	168		3	5	7	9	10	15	19	29	61	222	125
220	12	10							1	2	3	4	24	
	22	51				2	3	3	5	7	10	22	75	
	32	89		1	2	4	5	6	8	11	18	34	123	
	42	131		3	4	5	8	8	13	15	25	50	175	105
O2 TOX!!	52	174	2	4	5	7	11	11	17	20	32	66	228	136
		PPO2 Warning						1.26	1.10	1.53	1.28	1.3		

Dive Notes:	
Descent = 100 fsw/min to	Bottom
Ascent = 50 fsw/min to	First Deco
Ascent = 20 fsw/min from	Deco to Surface

Gas Notes:	
Descent Travel Gas is	Trimix 18 / 20 / 62 to Bottom
Bottom Gas is	Trimix 18 / 20 / 62
Ascent Gas is	Trimix 18 / 20 / 62 to 100fsw
Deco Gas is	Air at 100-90-80-70-60
Deco Gas is	EAN50 at 50-40-30
Deco Gas is	EAN80 at 20
Deco Gas is	100% O2 at 10

File—*Template General*

This option allows you to group together an entire set of Defaults and save them as a template. This allows you to create specific sets of default values for different types of diving. You might have one set for warm water tropical diving and another for cold water wreck diving. Once a group has been saved it can be reloaded for use on a new dive profile. The template is saved as part of the Dive Profile (*.DPD) as well as a separate template (*.DPT) file. This allows you to load any dive profile and the accompanying template will load automatically.

1. **Saving a Template**.

A. After having set all of your Default values, select "Save Template" from the bottom of the File menu.

B. Enter a unique name followed by the letters DPT (Dive Profile Template).

C. You may do this for as many separate sets of templates as you desire.

D. If you have changed any of the defaults settings during your Abyss session, upon exiting Abyss you will be asked if you want to save changes. These changes will be saved to the current template you have loaded in Abyss.

2. **Loading a Saved Template**:

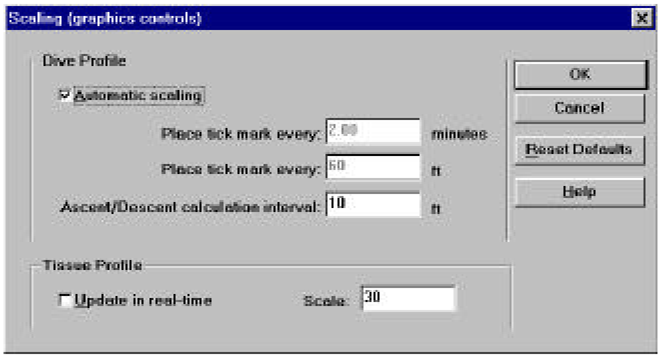
A. To use one of your saved templates select Load Template from the bottom of the File menu.

B. Select any of the saved templates and press the OK button.

C. Your current Defaults values are reset to match those of your saved template.

D. Once a template has been loaded it remains loaded even after you have exited Abyss.

File--*Scaling*



1. **Depth Scale:**

The Depth Scale allows you to specify the incremental depth value of the dive profile window. By increasing the tic value, you will increase the total viewable depth range on the dive planning window, but will lose resolution as the waypoints become closer and closer. Conversely, decreasing the tic value will decrease the maximum viewable depth range, but increase the resolution of the waypoints. In order to use this feature you must first disable the Scale-Auto option. Once you have disabled the Scale-Auto function you may type in the value, or use your mouse to adjust the incremental value.

a. Unselect **Scale-Auto**.
b. Place your mouse pointer on the word **FEET or METERS** in the dive profile window.
c. Click the **LEFT** mouse button to **DECREASE** the depth scale.
This causes the viewable resolution to decrease, but displays a greater range of depths.
d. Click the **RIGHT** mouse button to **INCREASE** the depth scale, showing less minutes.
This causes the viewable resolution to increase, but displays a smaller range of depths.

2. **Time Scale:**

The Time Scale allows you to specify the incremental time value of the dive profile window. By increasing the tic value, you will increase the total viewable time range on the dive planning window, but will lose resolution as the waypoints become closer and closer. Conversely, decreasing the tic value will decrease the maximum viewable time range, but increase the resolution of the waypoints. Once you have disabled the Scale-Auto function you may type in the value, or use your mouse to adjust the incremental value.

a. Unselect **Scale-Auto**.
b. Place your mouse pointer on the word **MINUTES** in the dive profile window.
c. Click the **LEFT** mouse button to **DECREASE** the time scale.
This causes the viewable resolution to decrease, but displays a larger range of time.
d. Click the **RIGHT** mouse button to **INCREASE** the time scale.
This causes the viewable resolution to increase, but displays a smaller range of time.

3. **Scale:**

This is the control for the relative size of the tissue array bars in the splitter window. By varying the scale ratio you will be able to increase or decrease the relative size of the tissue bars within the tissue array splitter window. Range is 1 to 1000, with 30 being the most commonly used.

4. **Real Time**:

This will allow you to see the actual ongassing/offgassing taking place as Abyss calculates it in real-time. This will slow Abyss down considerably, and will display values for 30sec time increments. If selected, this setting will be retained as a default setting until deselected.

5. **Descent/Ascent Calculation Interval**:

The calculation interval is the number of feet between samples that Abyss takes during the descent and ascent portions of your dive profile. This setting has NO effect on the calculations done for time spent at depth, only for the travel to and from depths. For best results the calculation should be set to 1 for maximum accuracy, 1 sample per foot. The default setting is 10, 1 sample every 10 feet, and is set for maximum system performance. While running Abyss begin decreasing the calculation interval in small steps until an acceptable performance rate is obtained. If changed, the new setting will be retained as a default setting until deselected.

6. **Calculation Interval of 1**.

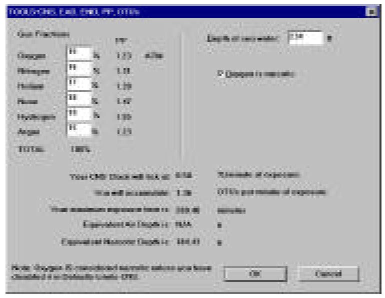
This setting offers you the maximum resolution that Abyss can provide while sampling your ongasing and offgasing. This also requires the most system resources and will tend to result in slower system operation.
Note: *This will result in the shortest and most accurate decompression times*.

7. **Calculation Interval of 10**.

This setting offers you the best general resolution that Abyss can provide while sampling your ongasing and offgasing. This requires less system resources and will tend to result in average system operation.
Note: *This will result in average decompression times*.
This is one of the few values in Abyss that IS NOT available in Metric Units. Our apologies if this causes you any inconvenience.

Tech Note: *If, in order to achieve acceptable system performance you must run the Calc interval at 10, consider installing a Math-Coprocessor in your system. You might also consider running your dive profiles at a Calc interval of 10 while working on the dive profile, and then changing the Calc Interval to a lower setting for a better final result.*

TOOLS—*CNS, END, Partial Pressure & OTUs*



The CNS & OTU calculator is a simple tool that will allow you to quickly determine at which rate your CNS Clock is ticking, and the rate of accumulation of OTUs.

1. **Depth of Sea Water**:
Enter the depth for which you would like to make the calculation.

2. **Oxygen IS narcotic?**
Select whether Oxygen is considered Narcotic or Non-Narcotic for the END calculations.

3. **Percentage of Gas**:
What are the percentages of the gases (oxygen, nitrogen, helium, etc.) that you will be breathing, and desire to run the calculation on?

4. **Partial Pressure**:
Your calculated partial Pressure in ATMs or BAR.
Abyss uses the following equation to determine Partial Pressures.
PPg=(Fg x (depth in feet/33 +1))
PPg=(Fg x (depth in meters/10 +1))

5. **CNS Clock Tick**:
This is the percentage of CNS exposure you will accumulate for every one minute spent at this exposure level.

6. **OTUs**:
This is the numb er of Oxygen Tolerance Units you will acquire for every one minute spent at this exposure level.

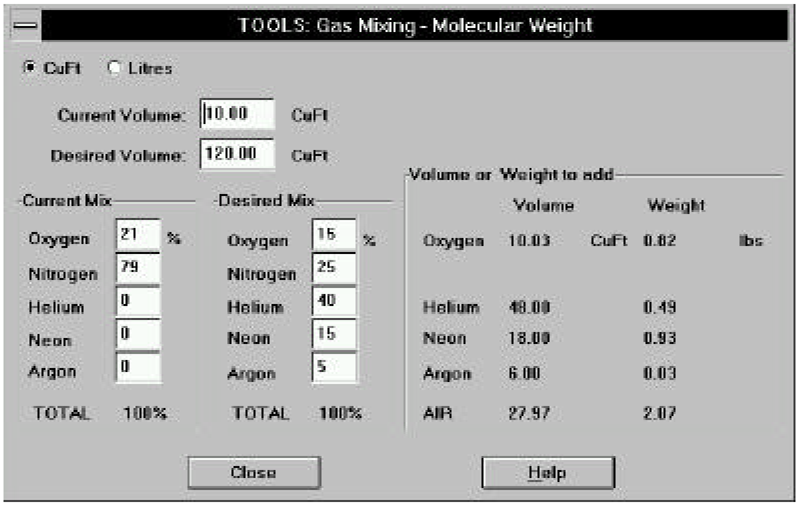
7. **Exposure:**
This is the estimated maximum time you could spend at this exposure level without exceeding either the CNS or OTU limitations.

8. **EAD:**
This is your Equivalent Air Depth. This figure is useful when breathing a Nitrox gas mixture, and planning the dive as though you were breathing Air on a fixed table. It is provided solely for your convenience, and has no practical application in Abyss.
Abyss uses the following simplified equation to determine EAD for this screen.
EAD=[((1.0-Fo2)/0.79)) x (Depth fsw + 33)]-33
EAD=[((1.0-Fo2)/0.79)) x (Depth m + 10)]-10

9. **END:**
This is your Equivalent Narcotic Depth. As many divers base their bottom gas mix on the level of tolerable narcosis, this figure gives you the equivalent narcotic depth of your breathing gas as compared to an Air mixture. Thus you may be at a depth of 220 feet on a Trimix, and your END may read shallower or deeper depending on the gases you have selected..

Tech Note: *Oxygen is about twice as lipid soluble as nitrogen, so it should theoretically be twice as narcotic. A very limited, controlled study suggests that oxygen is equipotent to nitrogen, and that the reason is possibly that much oxygen is bound to Hb, and is metabolized in the tissues. The weakness of this assumption is that oxygen and nitrogen may not be equally* *narcotic across all ratios and at all depths. Abyss uses the following relative narcotic values when computing your END.: Helium = 0, Neon = 0.28, Hydrogen = 0.55, Nitrogen = 1.00, Oxygen = 1.00, Argon = 2.33*

TOOLS--Gas Mixing, *Molecular Weight*



This Gas Mixing screen is designed to determine the weights of each gas you would need to add to a pressurized cylinder to obtain a specific final composition. Gas Mixing by Molecular weight is not affected by the compressibility of the gases, the rate of fill, the order in which the gases are added or the rise in temperature inside of the cylinder that cause the other mixing procedures to have errors. Molecular mixing is by <u>far the most accurate means</u> available to obtain a specific gas mixture, but it requires a high precision scale capable of 1 gram increments.

1. **<u>Cubic Feet or Liters</u>**:
   Which unit of volume do you measure your cylinder capacity in?.

2. **<u>Current Cylinder Volume</u>**:
   What is the current volume of gas in your cylinder, if empty (zero pressure) enter 0.?

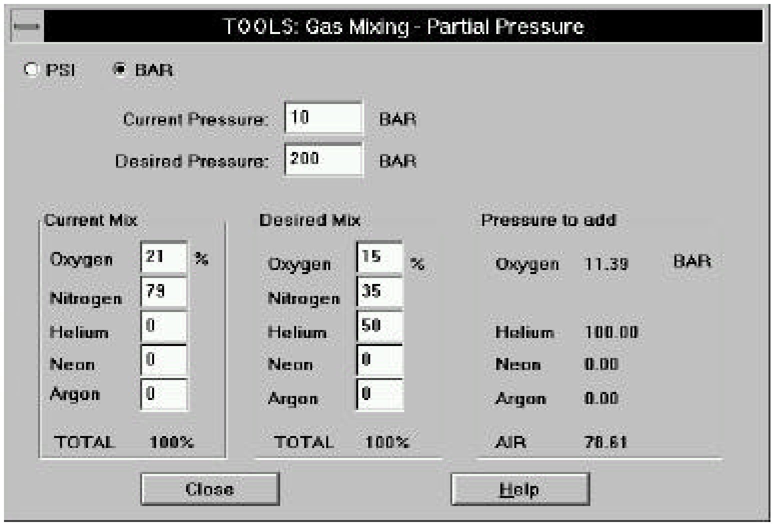
3. **<u>Desired Volume</u>**:
   What is the desired final fill volume for your cylinder?

4. **<u>Current Mixture</u>**:
   What is the composition of the gas mix in this cylinder?
   Enter the percentages of each gas.

5. **<u>Desired Mixture</u>**:
   What is the desired composition of the final gas mix for this cylinder?
   Enter the percentages of each gas.

6. **<u>Weight to Add</u>**:
   Add these weights of each of these gases to your cylinder to obtain your final desired mixture.

TOOLS--Gas Mixing**,** *Partial Pressure*



This Gas Mixing screen is designed to determine the partial pressures of each gas you would need to add to a pressurized cylinder to obtain a specific final composition. Gas Mixing by partial pressure is affected by the compressibility of the gases, the rate of fill, the order in which the gases are added and the rise in temperature inside of the cylinder, Each of these can cause this mixing procedure to have errors. Partial pressure mixing is by far the most common means used to obtain a specific gas mixture.

1. **PSI or BAR**:
   Which unit of pressure do you measure your cylinder in?.

2. **Current Cylinder Pressure**:
   What is the current pressure of gas in your cylinder, if empty (ambient pressure) enter 0.?

3. **Desired Pressure**:
   What is the desired final fill pressure for your cylinder?

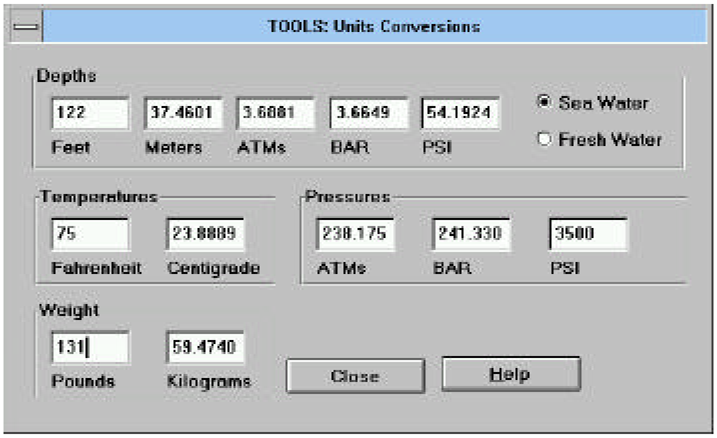
4. **Current Mixture**:
   What is the composition of the gas mix currently in this cylinder?
   Enter the percentages of each gas.

5. **Desired Mixture**:
   What is the desired composition of the final gas mix for this cylinder?
   Enter the percentages of each gas.

6. **Pressures to Add**:
   Add these pressures of each of these gases in this sequence to your cylinder to obtain your final desired mixture.

7. **Top with Air or EANx**:
   Allows you to specify whether you want to top your cylinder with regular AIR or to use a banked Nitrox mixture to achieve the required balance of Oxygen and Nitrogen to complete the mixing process.

TOOLS--*Units Conversions*



The Units Conversions tool is provided to give you a fast means of determining equivalent gas pressures and depth pressures.

1. **Pressures**:

Enter any known pressure, and all equivalents will be generated.

A. PSI, Pounds Per Square Inch.
B. ATM, Atmospheres.
C. BAR, .

2. **Depths:**

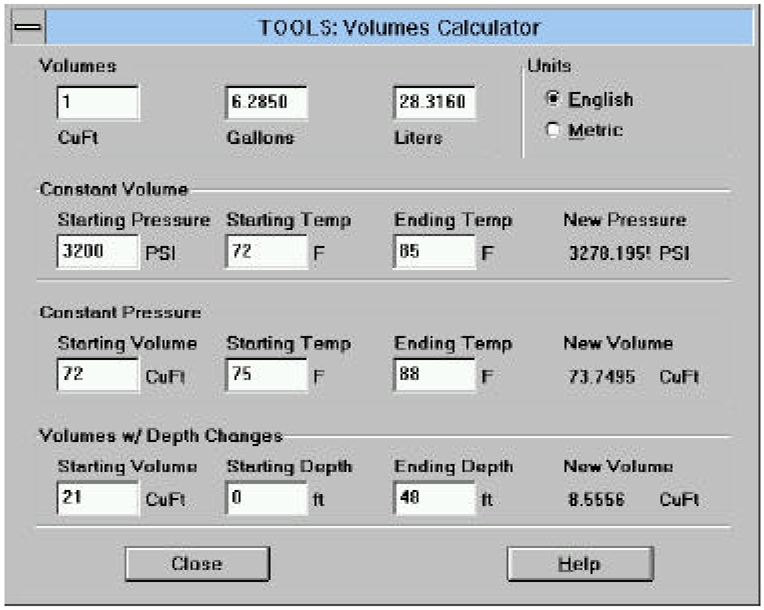
Select Fresh or Salt water, then enter a depth in distance or pressure, and all equivalents will be generated. It is important to understand that these fields are based on conversions to and from hyperbaric pressure units and not from linear measurements, thus there may be some conversions that appear strange. There are no agreed upon international conversion factors to go from Imperial Pressures to metric lengths or from Metric pressures to Imperial lengths.

A. Feet
B. Meters
C. ATM, atmospheres
D. BAR,
E, PSI, Pounds Per Square inch

3. **Temperatures:**

Enter the temperature in either Fahrenheit or Celsius, and the matching conversion will be displayed.

TOOLS--*Volumes*



The Volumes calculator allows you to determine simple conversions from Cu.ft./cu. in./Liters, the effects of temperature on pressure & volume, as well as the effect of depth on volume. This screen uses Ideal Gas laws for its calculations.

1. **Volumes**:
   Enter any known volume, and all equivalents will be generated.

2. **Constant Volume-Starting Pressure**:
   What is the beginning pressure in your cylinder?

3. **Constant Volume-Starting Temp**:
   What is the beginning temperature of your cylinder?

4. **Constant Volume-Ending Temp**:
   What is the ending temperature of your cylinder?

5. **Constant Pressure-Starting Volume**:
   How much gas is in the cylinder to start with?

6. **Constant Pressure-Starting Temp**:
   What is the beginning temperature of your cylinder?

7. **Constant Pressure-Ending Temp**:
   What is the ending temperature of your cylinder?

8. **Volume w/Depth-Starting Volume**:
   How much gas is in the cylinder to start with?

9. **Volume w/Depth-Depth**:
   What depth do you want to make the calculation?

TROUBLE SHOOTING

This is a list of common errors that you may see while using Abyss.

Abyss stops at Registration screen:
Your Demo or registration period has expired. Abyss has a limited amount of time or uses that it allows while unregistered. Once this period has elapsed you must register your copy of Abyss to continue using it.

Application Error: (Abyss has caused a General Protection Fault in module ABYSS.EXE.)
Abyss has generated a fatal incompatibility with your system. Shut down your computer and reboot. If you are able to recreate the identical error please call tech support.

Bad File Format:
Your default template is corrupt. Resave your template and then reload it.

Ctl3dv2.dll not properly installed:
This file controls the 3D look of many of the Abyss screens. This error indicates that during the initial installation of Abyss this file was not copied to your Windows/System sub-directory. Manually copy this file from the installation diskette to your Windows/System sub-directory.
Exp. Copy a:\ctl3dv2.dll c:\windows\system

Floating Point Error:
Abyss has attempted a mathematical operation that your computer cannot accomplish. Exit Abyss and then attempt the operation again, if you get the same error call tech support.

Liability Screen cannot be displayed:
The file “Liabilit.dat” has been damaged or is missing from your Abyss directory.

Liability screen will not proceed:
You are not entering the same initials on each page of the release.

Missing Units:
Your C:\Windows\Abyss.ini file has become corrupted. Delete the file, and Abyss will recreate a new one.

Screen does not function:
Check the window heading (top of the screen) for the words,
“*This window not supported in your version of Abyss*” or
“*This window is Inactive in version 1.4x of Abyss*.”

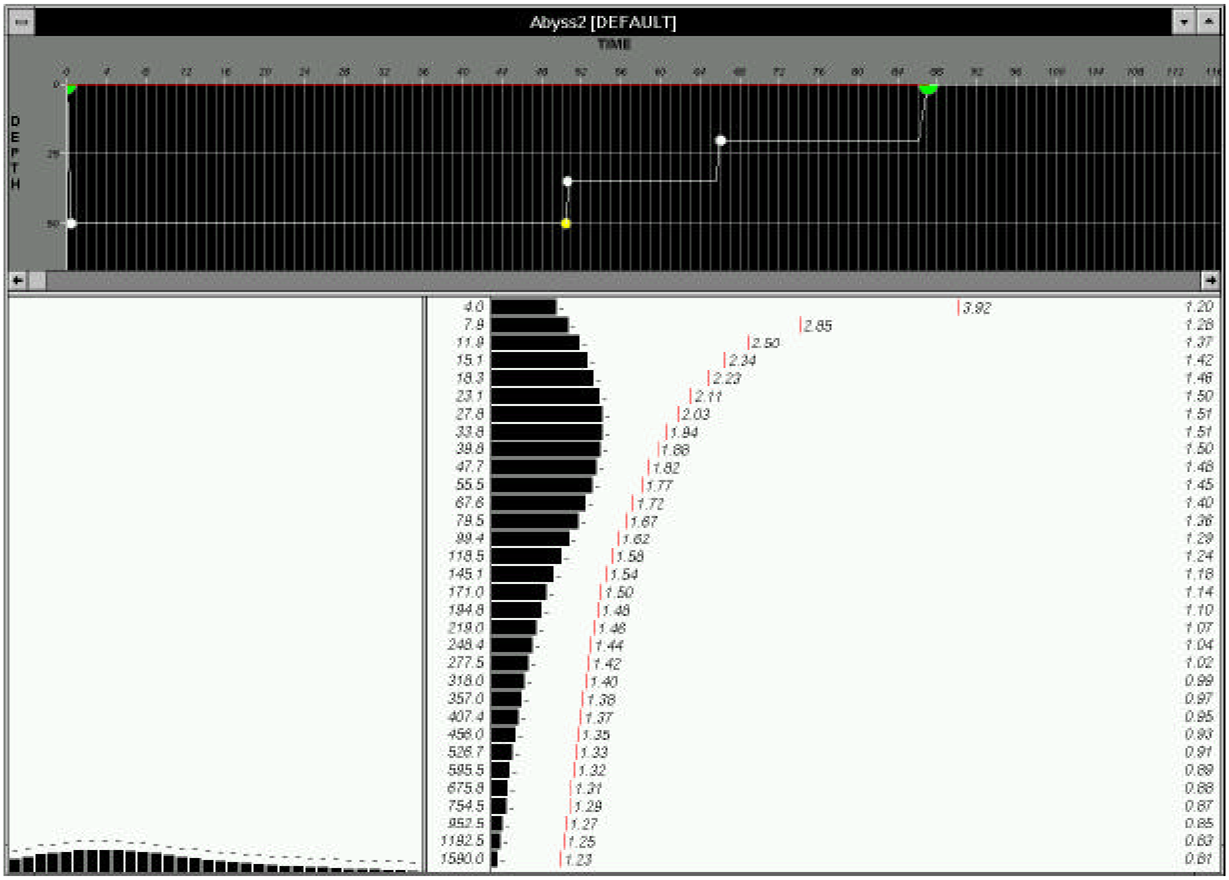
Unsupported File Format:
You have attempted to load an obsolete Dive Profile (*.DPD) or Template (*.DPT) file.

Your Deco time has exceeded 72 hours:
Abyss will not calculate any decompression schedule that requires more than 24 hours. Modify your dive profile and attempt to surface again.

TECH NOTE:
If you have an Application Error or a General Protection Fault, ***REBOOT YOUR COMPUTER!!.***
DO NOT CONTINUE USING ABYSS!!
MS-Windows is NOT fault tolerant, and often corrupts its memory management, resulting in bizarre and totally unusable

decompression schedules from Abyss
When in doubt, reboot the system, simply restarting Abyss is NOT sufficient!!

TUTORIAL--*Recreational Dive*



This is a brief tutorial to aquatint you with creating a recreational profile in Abyss, using all manual settings. A sample of this file can be found in the Samples directory in your Abyss sub-directory as REC.DPD

1. From the menu bar select the **Units** icon, and choose either Metric or Imperial.
2. Open a New Dive Profile Window by selecting **File New** from the menu bar.
3. Enter your **Surface Altitude**, this is zero (0) if you are at sea level.
4. Select your **Rate of Descent**, this is the rate from the surface to your first waypoint.
5. Enter the **Water Temperature**.
6. Set your **Workload** to Resting,
7. Is this a **Wreck or Cave penetration** dive, select NO for recreational O/W diving.
8. Select **Air** as your **Gas Mix**.
9. Click the **OK** button.

A new sub window called "Abyss 1" will now open. Maximize the size of this window and then adjust the size of the tissue array by dragging the mouse across the double line at the top of the tissue window until the mouse pointer changes to a pair of horizontal lines. Hold down the left mouse button and drag the tissue window to a comfortable size. Click on the tissue icon to activate "real-time" display of the tissue activity as it is occurring.

10. Create a New Waypoint by clicking your mouse on the black portion of the screen at a depth of 50 feet (as seen along the left-hand side of the screen).
This will cause the **New Stop Data** window to open.

11. Set **Current Depth** to 50 feet.
12. Set **Rate of Descent** to 75 feet per minute.
13. Set **Time at Depth** to 50 minutes.
Set **Water Temperature** (this allows you to indicate that a thermocline exists)

14. Click the OK button.

15. Create a New Waypoint at 35 feet.
16. Set **Current Depth** to 35 feet
17. Set **Rate of Ascent** to 75ft/min. (notice that the value is already entered from your previous entry or from your Defaults settings)
18. Set **Time at Depth** to 15 minutes.
19. Set **Water Temperature** (this allows you to indicate that a thermocline exists)
20. Set your **Workload** (notice that the value is already entered from your previous entry or from your Defaults settings)
21.. Click the OK button.

22. Create a **New Waypoint** at 20 feet.
23. Set **Current Depth** to 20 feet
24. Set **Rate of Ascent** to 75ft/min.
25. Set **Time at Depth** to 20 minutes.
26. Set **Water Temperature**
27. Set your **Workload**
28. Click the OK button.

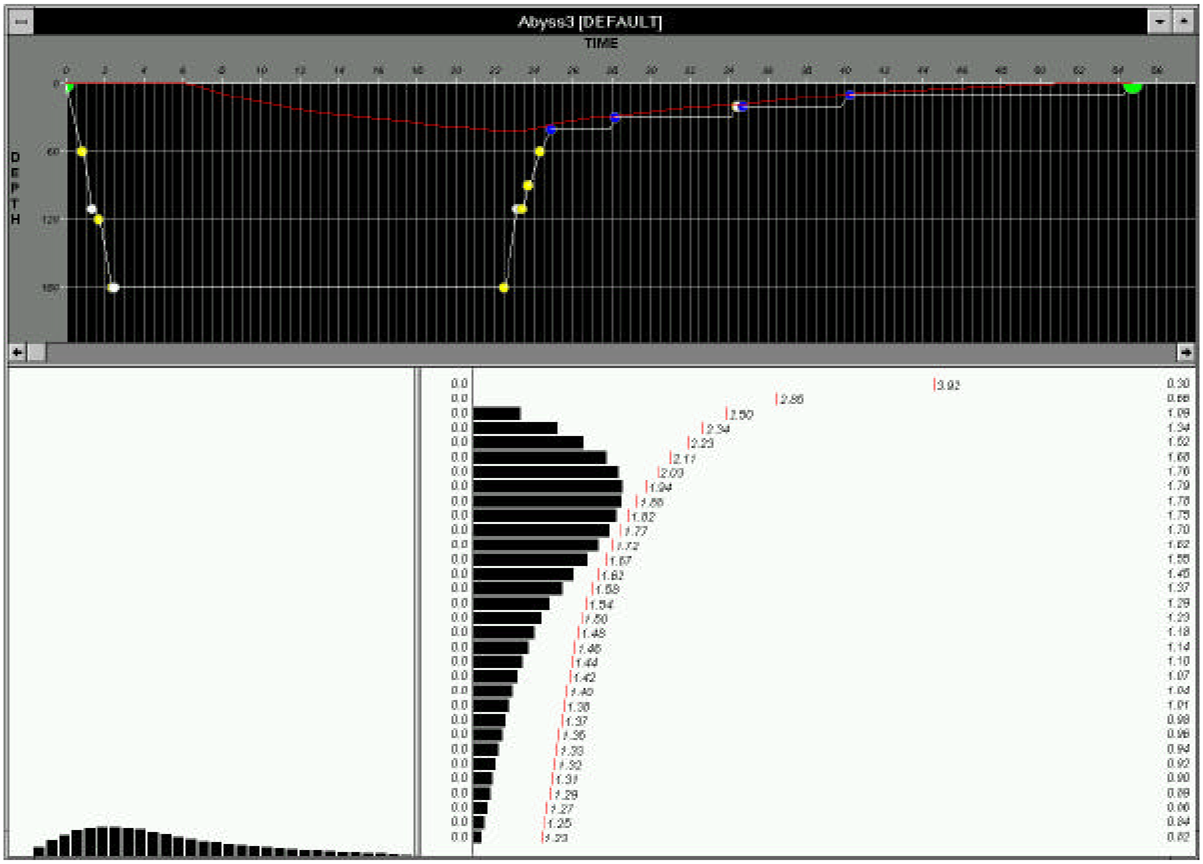
29. Create a **New Waypoint** at 0 feet by clicking the mouse along the white line at the zero depth mark.
30. Set **Current Depth** to 0 feet.
31. Click the OK button.

Congratulations, You have just completed your first dive profile.!!

32. With the mouse click on the waypoint at 50 feet. This will cause the **Modify Waypoint** screen to open displaying additional information about that point of your dive. Take a moment and look over all of the extra information you now have at your disposal.
33. Push the **Modify** button.
34. you are now back in the **New Stop Data** window where you can change any of your previous setting.
35. Change your depth to 100 feet and time at depth to 75 minutes.
36 Click the OK button.
37. Abyss now displays the warning “Need to decompress before Ascending”.
38. Click OK and notice that Abyss creates some new Blue waypoints indicating required decompression stops.

You have just modified your first dive profile.!!

TUTORIAL--*Technical Nitrox*



This is a brief tutorial to aquatint you with creating a Technical Nitrox profile in Abyss, using all manual settings. A sample of this file can be found in the Samples directory in your Abyss sub-directory as TECHNTX.DPD

1. From the menu bar select the **Units** icon, and choose either Metric or Imperial.
2. Open a New Dive Profile Window by selecting **File New** from the menu bar.
3. Enter your **Surface Altitude**, this is zero (0) if you are at sea level.
4. Select your **Rate of Descent**, this is the rate from the surface to your first waypoint.
5. Enter the **Water Temperature**.
6. Set your **Workload** to Resting,
7. Is this a **Wreck or Cave penetration** dive, select NO for recreational O/W diving.
8. Select Nitrox, **EANx 36** as your **Gas Mix**.
9. Click the OK button.

A new sub window called “Abyss 1” will now open. Maximize the size of this window and then adjust the size of the tissue array by dragging the mouse across the double line at the top of the tissue window until the mouse pointer changes to a pair of horizontal lines. Hold down the left mouse button and drag the tissue window to a comfortable size. Click on the tissue icon to activate “real-time” display of the tissue activity as it is occurring.

10. Create a New Waypoint by clicking your mouse on the black portion of the screen at a depth of 110 feet (as seen along the left-hand side of the screen).
This will cause the **New Stop Data** window to open.
11. Set **Current Depth** to 110 feet.
12. Set **Rate of Descent** to 75 feet per minute.
13. Set **Time at Depth** to 0.25 minutes.
Set **Water Temperature** (this allows you to indicate that a thermocline exists)

14. Select **Air** as your **Gas Mix**.
15. Click the OK button.

16. Create a New Waypoint at 180 feet.
17. Set **Current Depth** to 180 feet
18. Set **Rate of Ascent** to 75ft/min. (notice that the value is already entered from your previous entry or from your Defaults settings)
19. Set **Time at Depth** to 20 minutes.
20. Set **Water Temperature** (this allows you to indicate that a thermocline exists)
21. Set your **Workload** (notice that the value is already entered from your previous entry or from your Defaults settings)
22.. Click the OK button.

23. Create a **New Waypoint** at 110 feet.
24. Set **Current Depth** to 110 feet
25. Set **Rate of Ascent** to 75ft/min.
26. Set **Time at Depth** to 0.25 minutes.
27. Set **Water Temperature**
28. Set your **Workload**
29. Set gas mix to Nitrox **EANx 36**
30. Click the OK button.
31. Abyss now displays the warning "Need to decompress before Ascending".
32. Click OK and notice that Abyss creates some new Blue waypoints indicating required decompression stops.

33. Create a **New Waypoint** at 20 feet.
34. Set **Current Depth** to 20 feet.
35. Set **Rate of Ascent** to 20ft/min.
36. Set **Time at Depth** to 0.25 minutes.
37. Set **Water Temperature**
38. Set your **Workload**
39. Select **Nitrox** as your **Gas Mix**, and enter 80% Oxygen and 20% Nitrogen in the Gas Fractions field.
40. Click the OK button
41. Abyss again displays the warning "Need to decompress before Ascending".
42. Click OK and notice that Abyss creates a new Blue waypoint indicating a required decompression stop.

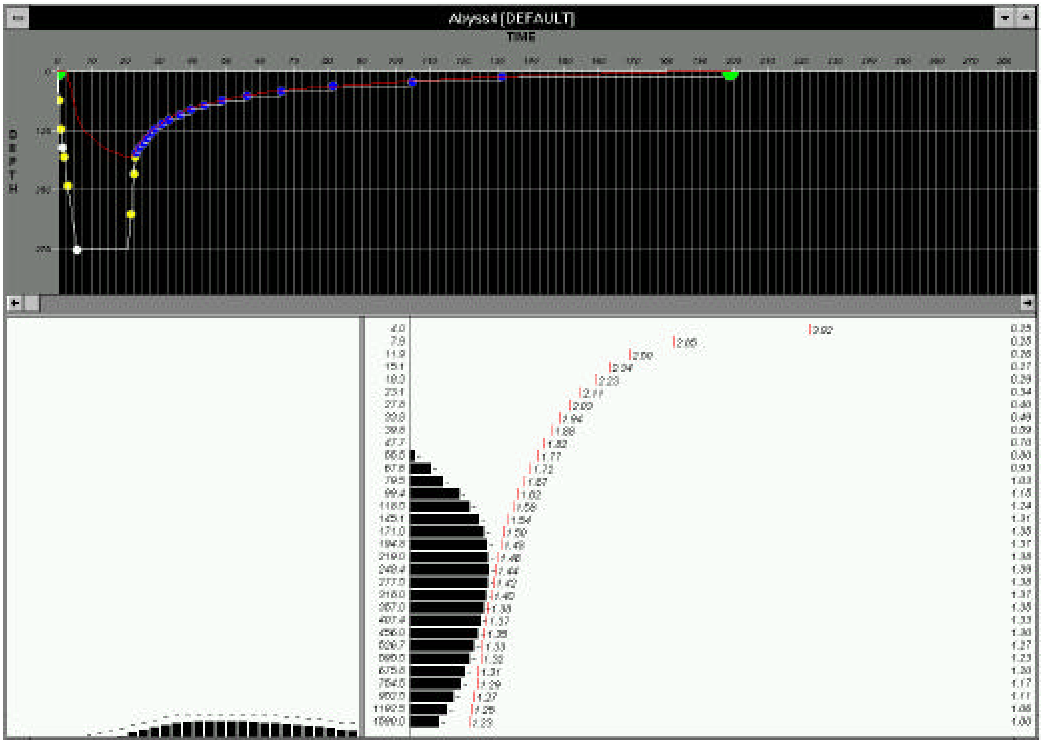
43. Create a **New Waypoint** at 0 feet by clicking the mouse along the white line at the zero depth mark.
44. Set **Current Depth** to 0 feet.
45. Click the OK button

Congratulations, You have just completed your first dive profile.!!

46. With the mouse click on the waypoint at 180 feet. This will cause the **Modify Waypoint** screen to open displaying additional information about that point of your dive. Take a moment and look over all of the extra information you now have at your disposal.
47. Push the **Modify** button.
48. You are now back in the **New Stop Data** window where you can change any of your previous settings.
49. Change your depth from 180 to 150 feet and time at depth from 20 to 15 minutes.
50 Click the OK button.
51. Abyss now steps you through each of the remaining waypoints..

Congratulations, you have just modified your first dive profile.!!

TUTORIAL--*Mixed Gas*



This is a simple tutorial to briefly aquatint you with creating a mixed gas profile in Abyss, using all manual settings. A sample of this file can be found in the Samples directory in your Abyss sub-directory as MIX.DPD

1. From the menu bar select the **Units** icon, and choose either Metric or Imperial.
2. Open a New Dive Profile Window by selecting **File New** from the menu bar.
3. Enter your **Surface Altitude**, this is zero (0) if you are at sea level.
4. Select your **Rate of Descent**, this is the rate from the surface to your first waypoint.
5. Enter the **Water Temperature**.
6. Set your **Workload** to Resting,
7. Is this a **Wreck or Cave penetration** dive, select NO for recreational O/W diving.
8. Select **Air** as your **Gas Mix**.
9. Click the **OK** button.

A new sub window called “Abyss 1” will now open. Maximize the size of this window and then adjust the size of the tissue array by dragging the mouse across the double line at the top of the tissue window until the mouse pointer changes to a pair of horizontal lines. Hold down the left mouse button and drag the tissue window to a comfortable size. Click on the tissue icon to activate “real-time” display of the tissue activity as it is occurring.

10. Create a New Waypoint by clicking your mouse on the black portion of the screen at a depth of 110 feet (as seen along the left-hand side of the screen).
This will cause the **New Stop Data** window to open.

11. Set **Current Depth** to 160 feet.
12. Set **Rate of Descent** to 75 feet per minute.
13. Set **Time at Depth** to 0.1 minutes.
14. Set **Water Temperature** (this allows you to indicate that a thermocline exists)
15 Click the OK button.
16. Select **Tri-mix** as your **Gas Mix**, and define as 10% O2, 40% Helium, 50% Nitrogen in the Gas Percentages field.

17. Create a New Waypoint at 325 feet.
18. Set **Current Depth** to 325 feet
19. Set **Rate of Ascent** to 75ft/min. (notice that the value is already entered from your previous entry or from your Defaults settings)
20. Set **Time at Depth** to 15 minutes.
21. Set **Water Temperature** (this allows you to indicate that a thermocline exists)
22. Set your **Workload** (notice that the value is already entered from your previous entry or from your Defaults settings)
23.. Click the OK button.

24. Create a **New Waypoint** at 215 feet.
25. Set **Current Depth** to 215 feet
26. Set **Rate of Ascent** to 75ft/min.
27. Set **Time at Depth** to 0.1 minutes.
28. Set **Water Temperature**
29. Set your **Workload**
30. Select **Air** as your **Gas Mix**.
31. Click the **OK** button.

32. Create a **New Waypoint** at 110 feet.
33. Set **Current Depth** to 110 feet
34. Set **Rate of Ascent** to 75ft/min.
35. Set **Time at Depth** to 0.1 minutes.
36. Set **Water Temperature**
37. Set your **Workload**
38. Select **Nitrox , EANx36** as your **Gas Mix**.
40. Click the **OK** button.
41. Abyss now displays the warning “Need to decompress before Ascending”.
42. Click **OK** and notice that Abyss creates some new Blue waypoints indicating required decompression stops.

43. Create a **New Waypoint** at 20 feet.
44. Set **Current Depth** to 20 feet.
45. Set **Rate of Ascent** to 20ft/min.
46. Set **Time at Depth** to 0.1 minutes.
47. Set **Water Temperature**
48. Set your **Workload**
49. Select **Nitrox 80/20** as your **Gas Mix**.
50. Click the **OK** button
51. Abyss again displays the warning “Need to decompress before Ascending”.
52. Click **OK** and notice that Abyss creates a new Blue waypoint indicating a required decompression stop.

53. Create a **New Waypoint** at 0 feet by clicking the mouse along the white line at the zero depth mark.
54. Set **Current Depth** to 0 feet.
55. Click the OK button

Congratulations, You have just completed your first dive profile.!!

56. With the mouse click on the waypoint at 375 feet. This will cause the **Modify Waypoint** screen to open displaying additional information about that point of your dive. Take a moment and look over all of the extra information you now have at your disposal.
Notice your END, CNS Clock and OTUs values.
57. Push the **Modify** button.
58. You are now back in the **New Stop Data** window where you can change any of your previous settings.
59. Change your depth from 375 to 275 feet and time at depth from 15 to 10 minutes.
60. Click the OK button.
61. Abyss now steps you through each of the remaining waypoints..
62. Click on the waypoint at 275 feet and notice the difference in your END/CNS/OTUs.

Congratulations, you have just modified your first dive profile.!!

Appendix, *International Technical Support*

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Article: ***R**educed **G**radient **B**ubble **M**odel*

Abyss incorporates RGBM

Dr. Bruce Wienke, Director of the Computation Testbed for Industry, Advanced Computing Laboratory at Los Alamos National Laboratory, and the creator of the RGBM (Reduced Gradient Bubble Model) has joined the Abysmal Diving team. Dr. Wienke will be assisting us in the implementation of his latest decompression model into Abyss.

This means that Abyss will be the first and only product in the world with a fully operational Bubble Mechanics model.
1. This will allow Abyss to more effectively handle Technical Repetitive decompression diving!!!(not a small issue in itself!!)
2. Dives in which the following dive is deeper than the first. (a real potential problem area).
3. This will also allow Abyss to run active tracking, in real time, of actual bubble growth based upon his published and proprietary unpublished research.

RGBM/ABYSS Implementation

The Reduced Gradient Bubble Model (RGBM) is a dual phase (dissolved and free gas) algorithm for diving calculations. Incorporating and coupling historical Haldanian dissolved gas transport with bubble excitation and growth, the RGBM extends the range of computational applicability of traditional methods. The RGBM is correlated with diving and exposure data on more complete physical principles. Much is new in the RGBM algorithm, and troublesome multidiving profiles with higher incidence of DCS are a target here. Some highlighted extensions for the ABYSS implementation of the Buhlmann basic algorithm include:

1. Standard Buhlmainiann nonstop time limits;

2. Restricted repetitive exposures, particularly beyond 100 ft, based on reduction in permissible bubble diffusion gradients within 2 hr time spans;

3. Restricted yo-yo and spike (multiple ascents and descents) dives based on excitation of new bubble seeds;

4. Restricted deeper-than-previous divers based on excitation of very small bubble seeds over 2 hr time spans:

5. Restricted multiday diving based on adaptation and regrowth of new bubble seeds;

6. Smooth coalescence of bounce and saturation limit points using 32 tissue compartments;

7. Consistent treatment of altitude diving, with proper zero point extrapolation of limiting tensions and permissible bubble gradients (through zero as pressure approaches zero);

8. Algorithm linked to diving data (tests), Doppler bubble, and laboratory micronuclei experiments;

9. Overall, parameters in RGBM/ABYSS are conservative, but flexible and easy to change or fit to new data.

What's in store for the future?

Quoting from Dr. Bruce Wienke..."The ultimate computational algorithm, coupling nucleation, dissolved gas uptake and elimination, bubble growth and collisional coalescence, and critical sites, would be very, very complicated, requiring supercomputers such as CRAYS or their massively parallel cousins CMs for three dimensional modeling. Stochastic Monte Carlo methods and sampling techniques exist which could generate and stabilize nuclei from the thermodynamic functions, such as Gibbs or Helmholtz free energy, transport dissolved gas in flowing blood to appropriate sites, inflate, deflate, move, and collide bubbles and nuclei, and then tally statistics on tensions, bubble size and number, inflation and coalescence rate, free phase volume, and any other meaningful parameter, all in necessary geometrics."

Such types of simulations of similarly complicated problems last for 16-32 hours at the Los Alimos Laboratories, on lightning fast supercomputers with near Gigaflop speed (1billion floating point operations per second)

Article: *Decompression Theory*

INTRODUCTION

Modeling of decompression phenomena in the human body is, at times, more of an artform than a science. Some take the view that deterministic modeling can only be fortuitous. technological advance, elucidation of competing mechanisms, and resolution of model issues over the past 80 years has not been rapid. Model applications tend to be ad hoc, tied to data fits, and difficult to quantify on first principles. Almost any description of decompression processes in tissue and blood can be disputed, and turned around on itself. The fact the decompression takes place in metabolic and perfused matter makes it difficult to design and analyze experiments outside living matter. Yet, for application to safe diving, we need models to build tables and meters. And deterministic models, not discounting shortcomings, are the subject of this discourse.

MODERN DIVING

A consensus of opinions, and for a variety of reasons, suggests that modern diving began in the early 1960s. Technological achievements, laboratory programs, military priorities, safety concerns, commercial diving requirements, and international business spurred diving activity and scope of operation. Diving bells, hot water heating, mixed gases, saturation, deep diving, expanded wet testing, computers, and efficient decompression algorithms signaled the modern diving era. Equipment advances in open and closed circuit breathing devices, wet and dry suits, gear weight, mask and fin design, high pressure compressors, flotation and buoyancy control vests, communications links, gauges and meters, lights, underwater tools (cutting, welding, drilling, explosives), surface supplied air, and photographic systems paced technological advances. Training and certification requirements for divers, in military, commercial, sport, and scientific sectors, took definition with growing concern for underwater safety and well being.

In the conquest and exploration of the oceans, saturation diving gained prominence in the 1960s, permitting exploitation of the continental shelf impossible with the short exposure times allowed by conventional diving. Spurred by both industrial and military interests in the ability of men to work underwater for long periods of time, notable habitat experiments, such as Sealab, Conshelf, Man In Sea, Gulf Task, Tektite, and Diogene, demonstrated the feasibility of living and working underwater for long periods of time. These efforts followed proof of principle validation, by Bond and coworkers (USN) in 1958, of saturation diving. Saturation exposure programs and tests have been conducted from 35 fsw to 2,000 fsw.

The development and use of underwater support platforms, such as habitats, bell diving systems, lockout and free flooded submersibles, and diver propulsion units also accelerated in the 1960s and 1970s, for reasons of science and economics. Support platforms extended both diver usefulness and bottom time, by permitting him to live underwater, reducing descent and ascent time, expanding mobility, and lessening physical activity. Today, themselves operating from underwater platforms, remotely operated vehicles (ROVs) scan the ocean depths at 6,000 fsw for minerals and oil.

Around 1972, strategies for diving in excess of 1,000 fsw received serious scrutiny, driven by a commercial quest for oil and petroleum products, and the needs of the commercial diving industry to service that quest. Questions concerning pharmacological additives, absolute pressure limits, thermal exchange, therapy, compression-decompression procedures, effective combinations of mixed breathing gases, and equipment functionality addressed many fundamental issues, unknown or only partially understood. By the early 1980s, it became clear that open sea water work in the 1,000 to 2,000 fsw range was entirely practical, and many of the problems, at least from an operational point of view, could be solved. Today, the need for continued deep diving remains, with demands that cannot be answered with remote, or 1 atm, diver systems. Heliox and trimix have become standards for deep excursion breathing gases, with heliox the choice for shallower exposures, and trimix the choice for deeper exposures in the field.

Yet, despite tremendous advances in deep diving technology, most of the ocean floor is outside human reach. Breathing mixtures that are compressible are limiting. Breathing mixtures that are not compressible offer interesting alternatives. In the 1960s, serious attention was given to liquid breathing mixtures, physiological saline solutions. Acting as inert respiratory gas diluents, oxygenated fluids have been used as breathing mixtures, thereby eliminating decompression requirements.

MODELS

Most believe that the pathophysiology of decompression sickness syndrome follows formation of a gas phase after decompression. Yet, the physiological evolution of the gas phase is poorly understood. Bubble detection technology has established that moving and stationary bubbles do occur following decompression, that the risk of decompression sickness increases with the magnitude of detected bubbles, that symptomless, or silent, bubbles are also common following decompression, and that the variability in gas phase formation is likely less than the variability in symptom generation. Taken together, gas phase formation is not only important to the understanding of decompression sickness, but is also a crucial model element in theory and computation.

Bubbles can form in tissue and blood when ambient pressure drops below tissue tensions, according to dis solved-free phase mechanics. Trying to track free and dissolved gas buildup and elimination in tissue and blood, especially their interplay, is extremely complex, beyond the capabilities of even supercomputers. But safe computational prescriptions are necessary in the formulation of dive tables and digital meter algorithms. The simplest way to stage decompression, following extended exposures to high pressure with commensurate dissolved gas buildup, is to limit tissue tensions. Historically, Haldane first employed the approach, and it persists today in modified form.

History

Tables and schedules for diving at sea level can be traced to a model proposed in 1908 by the eminent English physiologist, John Scott Haldane. He observed that goats, saturated to depths of 165 feet of sea water (fsw), did not develop decompression sickness (DCS) if subsequent decompression was limited to half the ambient pressure. Extrapolating to humans, researchers reckoned that tissues tolerate elevated dissolved gas pressures (tensions), greater than ambient by factors of two, before the onset of symptoms. Haldane then constructed schedules which limited the critical supersaturation ratio to two in hypothetical tissue compartments. Tissue compartments were characterized by their halftime, tau . Halftime is also termed half-life when linked to exponential processes, such as radioactive decay. Five compartments (5, 10, 20, 40, 75 minutes) were employed in decompression calculations and staged procedures for fifty years.

Some years following, in performing deep diving and expanding existing table ranges in the 1930s, US Navy investigators assigned separate limiting tensions (M-values) to each tissue compartment. Later in the 1950s and early 1960s, other US Navy investigators, in addressing repetitive exposures for the first time, advocated the use of six tissues (5, 10, 20, 40, 80, 120 minutes) in constructing decompression schedules, with each tissue compartment again possessing its own limiting tension. Temporal uptake and elimination of inert gas was based on mechanics addressing only the macroscopic aspects of gas exchange between blood and tissue. Exact bubble production mechanisms, interplay of free and dissolved gas phases, and related transport phenomena were not quantified, since they were neither known nor understood. Today, we know much more about dissolved and free phase dynamics, bubbles, and transport mechanisms, but still rely heavily on the Haldane model. Inertia and simplicity tend to sustain its popularity and use, and it has been a workhorse.

To maximize the rate of uptake or elimination of dissolved gases, the gradient, simply the difference between arterial and tissue tension, is maximized by pulling the diver as close to the surface as possible. Exposures are limited by requiring that the tissue tensions, never exceed limits (called M-values), for instance, written for each compartment in the US Navy approach (5, 10, 20, 40, 80, and 120 minute tissue halftimes, tau , as M = M sub 0 + DELTA M d, with, M sub 0 = 152.7 tau sup -1/4 , and, DELTA M = 3.25 tau sup -1/4 , as a function of depth, d, for DELTA M the change per unit depth. Obviously, M, is largest for fast tissue compartments (tau small), and smallest for slow tissue compartments (tau large). Fast compartments control short deep excursions, while slow compartments control long shallow excursions. Surfacing values, M sub 0 , are principal concerns in nonstop diving, while values at depth, DELTA M d , concern decompression diving. In both cases, the staging regimen tries to pull the diver as close to the surface as possible, in as short a time as possible. By contrast, free phase (bubble) elimination gradients, as seen, increase with depth, directly opposite to dissolved gas elimination gradients which decrease with depth. In actuality, decompression is a playoff between dissolved gas buildup and free phase growth, tempered by body ability to eliminate both. But dissolved gas models cannot handle both, so there are problems when extrapolating outside tested ranges.

In absolute pressure units, the corresponding critical gradient, G = Q - P, is related to ambient pressure, P, and critical nitrogen pressure, M, with, Q = 1.27 M. In bubble theories, supersaturation is limited by the critical gradient, G. In decompressed gel experiments, Strauss suggested that G approx. 20 fsw at ambient pressures less than a few atmospheres. Other studies suggest, 14 <= G <= 30 fsw, as a range of critical gradients (G-values). In diffusion-dominated approaches, the tissue tension can be limited by a single, pressure criterion, such as, M = 709 P / P + 404 .

Blood rich, well-perfused, aqueous tissues are usually thought to be fast (small τ), while blood poor, scarcely-perfused, lipid tissues are thought to be slow (large τ), though the spectrum of halftimes is not correlated with actual perfusion rates in critical tissues. As reflected in relationship above, critical parameters are obviously larger for faster tissues. The range of variation with compartment and depth is not insignificant. Fast compartments control short deep exposures, while slow compartments control long shallow, decompression, and saturation exposures.

Bulk Diffusion Model

Diffusion limited gas exchange is modeled in time by a sum of exponential response functions, bounded by arterial and initial tissue tensions. However, instead of many tissue compartments, a single bulk tissue is assumed for calculations, characterized by a gas diffusion constant, D. Tissue is separated into intravascular (blood) and extravascular (cells) regions. Blood containing dissolved inert and metabolic gases passes through the intravascular zone, providing initial and boundary conditions for subsequent gas diffusion into the extravascular zone. Diffusion is driven by the difference between arterial and tissue tensions, according to the strength of a single diffusion coefficient, D, appropriate to the media. Diffusion solutions, averaged over the tissue domain, resemble a weighted sum over effective tissue compartments with time constants, $\alpha_{2n-1}^2 D$, determined by diffusivity and boundary conditions, with $\alpha_{2n-1} = (2n-1)\pi / l$ for tissue thickness, l.

Applications fit the time constant, $K = \pi^2 D / l^2$, to exposure data, with a typical value employed by the Royal Navy given by, $K = 0.007928\ \text{min}^{-1}$, approximating the US Navy 120 minute compartment used to control saturation, decompression, and repetitive diving. Corresponding critical tensions in the bulk model, $M = 709 P / P + 404$, fall somewhere between fixed gradient and multitissue values. At the surface, M = 53 fsw, while at 200 fsw, M = 259 fsw. A critical gradient, $G = P(493 - P) / (P + 404)$, also derives from the above. Originally, a critical gradient, G, near 30 fsw was used to limit exposures. Such value is too conservative for deep and bounce exposures, and not conservative enough for shallow exposures. Hempleman introduced the above relationship, providing the means to parameterize bounce and saturation diving.

Bulk models are attractive because they permit the whole dive profile to be modeled with one equation, and because they predict a $t^{1/2}$ behavior of gas uptake and elimination. Nonstop time limits, t_n, are related to depth, d, by the bulk diffusion relationship, $d\, t_n^{1/2} = C$, with approximate range, $400 \le C \le 500\ \text{fsw min}^{1/2}$, linking nonstop time and depth simply through the value of C. For the US Navy nonstop limits, $C \approx 500\ \text{fsw min}^{1/2}$, while for the Spencer reduced limits, $C \approx 465\ \text{fsw min}^{1/2}$. In the Wienke-Yount model, $C \approx 400\ \text{fsw min}^{1/2}$.

Multitissue Model

Multitissue models, variations of the original Haldane model, assume that dissolved gas exchange, controlled by blood flow across regions of varying concentration, is driven by the local gradient, that is, the difference between the arterial blood tension and the instantaneous tissue tension. Tissue response is modeled by exponential functions, bounded by arterial and initial tensions, and perfusion constants, λ, linked to the tissue halftimes, τ, for instance, 1, 2, 5, 10, 20, 40, 80, 120, 180, 240, 360, 480, and 720 minute compartments assumed to be independent of pressure.

In a series of dives or multiple stages, initial and arterial tensions represent extremes for each stage, or more precisely, the initial tension and the arterial tension at the beginning of the next stage. Stages are treated sequentially, with finishing tensions at one step representing initial tensions for the next step, and so on. To maximize the rate of uptake or elimination of dissolved gases the gradient, simply the difference between arterial and tissue tensions is maximized by pulling the diver as close to the surface as possible. Exposures are limited by requiring that the tissue tensions never exceed $M = M_0 + \Delta M\, d$, as a function of depth, d, for ΔM the change per unit depth. A set of M_0 and ΔM are listed in Table 1.

At altitude, some critical tensions have been correlated with actual testing, in which case, an effective depth, $d = P - 33$, is referenced to the absolute pressure, P, with surface pressure, $P_h = 33 \exp(-0.0381\, h)$, at elevation, h, and h in multiples of 1,000 ft. However, in those cases where critical tensions have not been tested, nor extended, to altitude, an exponentially decreasing extrapolation scheme, called similarity, has been employed. Extrapolations of critical tensions, below P = 33 fsw, then fall off more rapidly then in the linear case. A similarity extrapolation holds the ratio, R = M/P, constant at altitude. Estimating minimum surface tension pressure of bubbles near 10 fsw, as a limit point, the similarity extrapolation might be limited to 10,000 ft in elevation, and neither for decompression nor heavy repetitive diving.

Models of dissolved gas transport and coupled bubble formation are not complete, and all need correlation with experiment and wet testing. Extensions of basic (perfusion and diffusion) models can redress some of the difficulties and deficiencies, both in theory and application. Concerns about microbubbles in the blood impacting gas elimination, geometry of the tissue region with respect to gas exchange, penetration depths for gas diffusion, nerve deformation trigger points for pain, gas uptake and elimination asymmetry, effective gas exchange with flowing blood, and perfusion versus diffusion limited gas exchange, to name but a few, motivate a number of extensions of dissolved gas models.

The multitissue model addresses dissolved gas transport with saturation gradients driving the elimination. In the presence of free phases, free-dissolved and free-blood elimination gradients can compete with dissolved-blood gradients. One suggestion is that the gradient be split into two weighted parts, the free- blood and dissolved-blood gradients, with the weighting fraction proportional to the amount of separated gas per unit tissue volume. Use of a split gradient is consistent with multiphase flow partitioning, and implies that only a portion of tissue gas has separated, with the remainder dissolved. Such a split representation can replace any of the gradient terms in tissue response functions.

If gas nuclei are entrained in the circulatory system, blood perfusion rates are effectively lowered, an impairment with impact on all gas exchange processes. This suggests a possible lengthening of tissue halftimes for elimination over those for uptake, for instance, a 10 minute compartment for uptake becomes a 12 minute compartment on elimination. Such lengthening procedure and the split elimination gradient obviously render gas uptake and elimination processes asymmetric. Instead of both exponential uptake and elimination, exponential uptake and linear elimination response functions can be used. Such modifications can again be employed in any perfusion model easily, and tuned to the data.

Thermodynamic Model

The thermodynamic approach suggested by Hills, and extended by others, is more comprehensive than earlier models, addressing a number of issues simultaneously, such as tissue gas exchange, phase separation, and phase volume trigger points. This model is based on phase equilibration of dissolved and separated gas phases, with temporal uptake and elimination of inert gas controlled by perfusion and diffusion. From a boundary (vascular) zone of thickness, gases diffuse into the cellular region. Radial, one dimensional, cylindrical geometry is assumed as a starting point, though the extension to higher dimensionality is straightforward. As with all dissolved gas transfer, diffusion is controlled by the difference between the instantaneous tissue tension and the venous tension, and perfusion is controlled by the difference between the arterial and venous tension. A mass balance for gas flow at the vascular cellular interface, a, enforces the perfusion limit when appropriate, linking the diffusion and perfusion equations directly. Blood and tissue tensions are joined in a complex feedback loop. The trigger point in the thermodynamic model is the separated phase volume, related to a set of mechanical pain thresholds for fluid injected into connective tissue.

The full thermodynamic model is complex, though Hills has performed massive computations correlating with the data, underscoring basic model validity. Considerations of free phase dynamics (phase volume trigger point) require deeper decompression staging formats, compared to considerations of critical tensions, and are characteristic of phase models. Full blown bubble models require the same, simply to minimize bubble excitation and growth.

Reduced Gradient Bubble Model

The reduced gradient bubble model (RGBM), developed by Wienke, treats both dissolved and free phase transfer mechanisms, postulating the existence of gas seeds (micronuclei) with permeable skins of surface active molecules, small enough to remain in solution and strong enough to resist collapse. The model is based upon laboratory studies of bubble growth and nucleation, and grew from a similar model, the varying permeability model (VPM), treating bubble seeds as gas micropockets contained by pressure permeable elastic skins

Inert gas exchange is driven by the local gradient, the difference between the arterial blood tension and the instantaneous tissue tension. Compartments with 1, 2, 5, 10, 20, 40, 80, 120, 240, 480, and 720 halftimes, tau , are again employed. While, classical (Haldane) models limit exposures by requiring that the tissue tensions never exceed the critical tensions, fitted to the US Navy nonstop limits, for example. The reduced gradient bubble model, however, limits the supersaturation gradient, through the phase volume constraint. An exponential distribution of bubble seeds, falling off with increasing bubble size is assumed to be excited into growth by compression-decompression. A critical radius, r sub c , separates growing from contracting micronuclei for given ambient pressure, P sub c . At sea level, P sub c = 33 fsw , r sub c = .8 microns, and DELTA P = d. Deeper decompressions excite smaller, more stable, nuclei.

This section applies to all versions.

Within a phase volume constraint for exposures, a set of nonstop limits, t sub n , at depth, d, satisfy a modified law, d t sub n sup 1/2 = 400 fsw min sup 1/2 , with gradient, G, extracted for each compartment, tau , using the nonstop limits and excitation radius, at generalized depth, d = P - 33 fsw. Tables 2 and 3 summarize t sub n , G sub 0 , DELTA G , and delta , the depth at which the compartment begins to control exposures.

Table 2. Critical Phase Volume Time Limits.

depth d(fsw)	nonstop limit t sub n (min)	depth d (fsw)	nonstop limit t sub n (min)
30	250	130	9.
40	130.	140	8.
50	73.	150	7.
60	52.	1606	5
70	39.	1705	8
80	27.	1805	3
90	22.	1904	6
100	18.	2004	1
110	15.	2103	7
120	12.	2203	1

Gas filled crevices can also facilitate nucleation by cavitation. The mechanism is responsible for bubble formation occurring on solid surfaces and container walls. In gel experiments, though, solid particles and ragged surfaces were seldom seen, suggesting other nucleation mechanisms. The existence of stable gas nuclei is paradoxical. Gas bubbles larger than 1 micron should float to the surface of a standing liquid or gel, while smaller ones should dissolve in a few seconds. In a liquid supersaturated with gas, only bubbles at the critical radius, r sub c , would be in equilibrium (and very unstable equilibrium at best). Bubbles larger than the critical radius should grow larger, and bubbles smaller than the critical radius should collapse. Yet, the Yount gel experiments confirm the existence of stable gas phases, so no matter what the mechanism, effective surface tension must be zero.

Table 3. Critical Phase Volume Gradients.

halftime tau (min)	threshold depth delta (fsw)	surface gradient G sub 0 (fsw)	gradient change DELTA G
2	190	151.0	.518
5	135	95.0	.515
10	95	67.0	.511
20	65	49.0	.506
40	40	36.0	.468
80	30	27.0	.417
120	28	24.0	.379
240	16	23.0	.329
480	12	22.0	.312

Although the actual size distribution of gas nuclei in humans is unknown, these experiments in gels have been correlated with a decaying exponential (radial) distribution function. For a stabilized distribution accommodated by the body at fixed pressure, P sub c , the excess number of nuclei excited by compression-decompression must be removed from the body. The rate at which gas inflates in tissue depends upon both the excess bubble number, and the supersaturation gradient, G. The critical volume hypothesis requires that the integral of the product of the two must always remain less than some volume limit point, alpha V , with alpha a proportionality constant. A conservative set of bounce gradients, G bar , can be also be extracted for multiday and repetitive diving, provided they are multiplicatively reduced by a set of bubble factors, eta sup rep, eta sup reg , eta sup exc , all less than one, such that G bar = eta sup rep eta sup reg eta sup exc G.

These three bubble factors reduce the driving gradients to maintain the phases volume constraint. The first bubble factor reduces G to account for creation of new stabilized micronuclei over time scales of days. The second factor accounts for additional micronuclei excitation on deeper-than-previous dives. The third bubble factor accounts for bubble growth over repetitive exposures on time scales of hours. Clearly, the repetitive factors, eta sup rep , relax to one after about 2 hours, while the multiday factors, eta sup reg , continue to decrease with increasing repetitive activity, though at very slow rate. Increases in bubble elimination halftime and nuclei regeneration halftime will tend to decrease eta sup rep and increase eta sup reg . The repetitive fractions, eta sup rep , restrict back to back repetitive activity considerably for short surface intervals. The multiday fractions get small as multiday activities increase continuously beyond 2 weeks. Deeper-than-previous excursions incur the greatest reductions in permissible gradients (smallest eta sup exc) as the depth of the exposure exceeds previous maximum depth.

Tissue Bubble Diffusion Model

The tissue bubble diffusion model (TBDM), according to Gernhardt and Vann, considers the diffusive growth of an extravascular bubble under arbitrary hyperbaric and hypobaric loadings. The approach incorporates inert gas diffusion across the tissue-bubble interface, tissue elasticity, gas solubility and diffusivity, bubble surface tension, and perfusion limited transport to the tissues. Tracking bubble growth over a range of exposures, the model can be extended to oxygen breathing and inert gas switching. As a starting point, the TBDM assumes that, through some process, stable gas nuclei form in the tissues during decompression, and subsequently tracks bubble growth with dynamical equations. Diffusion limited exchange is invoked at the tissue-bubble interface, and perfusion limited exchange is assumed between tissue and blood, very similar to the thermodynamic model, but with free phase mechanics. Across the extravascular region, gas exchange is driven by the pressure difference between dissolved gas in tissue and free gas in the bubble, treating the free gas as ideal. Initial nuclei in the TBDM have assumed radii near 3 microns at sea level, to be compared with .8 microns in the RGBM.

As in any free phase model, bubble volume changes become more significant at lower ambient pressure, suggesting a mechanism for enhancement of hypobaric bends, where constricting surface tension pressures are smaller than those encountered in hyperbaric cases. For instance, a theoretical bubble dose of 5 ml correlates with a 20% risk of decompression sickness, while a 35 ml dose correlates with a 90% risk, with the bubble dose representing an unnormalized measure of the separated phase volume. Coupling bubble volume to risk represents yet another extension of the phase volume hypothesis, a viable trigger point mechanism for bends incidence.

SATURATION CURVE

The saturation curve, relating permissible gas tension, Q, as a function of ambient pressure, P, for air, sets a lower bound, so to speak, on decompression staging. All staging models and algorithms must collapse to the saturation curve as exposure times increase in duration. In short, the saturation curve represents one extreme for any staging model. Bounce curves represent the other extreme. Joining them together for diving activities in between is a model task, as well as joining the same sets of curves over varying ambient pressure ranges. In the latter case, extending bounce and saturation curves to altitude is just such an endeavor.

Models for controlling hypobaric and hyperbaric exposures have long differed over range of applicability. Recent analyses of very high altitude washout data question linear extrapolations of the hyperbaric saturation curve, to hypobaric exposures, pointing instead to correlation of data with constant decompression ratios in animals and humans. Correlations of hypobaric and hyperbaric data, however, can be effected with a more general form of the saturation curve, one exhibiting the proper behavior in both limits. Closure of hypobaric and hyperbaric diving data can be managed with one curve, exhibiting linear behavior in the hyperbaric regime, and bending through the origin in the hypobaric regime. Using the RGBM and a basic experimental fact that the number of bubble seeds in tissue increase exponentially with decreasing bubble radius, just such a single expression can be obtained. The limiting forms are exponential decrease with decreasing ambient pressure (actually through zero pressure), and linear behavior with increasing ambient pressure. Asymptotic forms are quite evident. Such general forms derive from the RGBM, depending on a coupled treatment of both dissolved and free gas phases. Coupled to the phase volume constraint, these models suggest a consistent means to closure of hypobaric and hyperbaric data.

DECOMPRESSION MODELS AND PHASE MECHANICS

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Article: Argon Usage

INTRODUCTION

Argon has been used mostly experimentally as a diluent during decompression. However it is highly soluble and is very narcotic compared to nitrogen and helium. Argon's narcotic potency is about twice that of air. The premise for considering argon was due to its slower diffusion rate into tissue compared to nitrogen and helium. One current decompression model (Buhlmann) suggests the diffusion of an inert gas into tissue is inversely related to the square root of the mo lecular weight of the gas. For example if you compare this ratio for helium with the ratio for nitrogen you would find the helium ratio is 2.65 times the nitrogen ratio. Similarly if you compare nitrogen to argon, you would find the nitrogen ratio is about 1.19 times the argon ratio. What does this mean?

For example, if you look at the 4th compartment (tissue group)of the Buhlmann ZH-L12, 12 compartment decompression model you will find the "half-time" for helium to be 7 minutes and the half-time for nitrogen to be 18.5 minutes. The helium time is 2.65 times faster than the nitrogen time. Amazing! You could extrapolate this information and conclude the half-time for argon for this compartment would be 22 minutes. According to the Buhlmann model the increase in the compartment gas tension (pressure) is a function of the ambient pressure, the time of exposure, and the half-time for the gas being considered. Thus for an equal time of exposure and ambient pressure the gas with the highest half-time would on-gas slower, and off-gas slower. This of course only considers the exponential-exponential hypothesis (exponential on-gas and exponential off-gas).

Buhlmann simplified his theory by suggesting the total inert gas pressure, the sum of the inert gas partial pressures in the tissue, determines the tolerated ambient pressure during decompression. This sum of the inert gas pressures is subtracted and multiplied respectively by Bühlmann's "a & b" coefficients to derive the tolerated ambient pressure (similar to "M" values in the Haldane based models). The tolerated ambient pressure is the decompression ceiling; if you ascend above the ceiling, decompression sickness may ensue. Stopping at the ceiling (decompression stop) will allow more gas to off-gas and the ceiling (tolerated ambient pressure) will move shallower until you can exit the water.

Since argon diffuses into tissue slower, the replacement of nitrogen/helium with argon during decompression would create a situation where the argon is on-gasing slower than the nitrogen and/or helium is off-gasing. This mechanism is referred to as counter-diffusion. This can occur to the degree where the total inert gas pressure in the tissue is less than the surrounding ambient pressure (fraction of inert gas in breathing mixture times the ambient pressure). This process works to shorten the decompression time. The same situation exists during gas switching from high helium content bottom mixes to air. Your decompression obligation can be significantly reduced by switching to air as deep as safely practical because the helium (2.65 times faster than nitrogen) is off-gasing rapidly while nitrogen is on-gasing more slowly.

Digressing a bit, its should be noted the reverse process of switching from a heavier inert gas to a lighter inert gas (e.g. nitrogen to helium)can create a "super-saturated" condition, where the tissue inert gas pressure is greater than the ambient inert gas pressure, even with no change in depth from the switch! This is the basis of lengthy and often misguided discussions on isobaric inert gas counterdiffusion.

To cut to the chase, using argon may shorten your decompression somewhat; however the amount of reduction may not be considered significant due to the relatively small difference in diffusion half-times between argon and nitrogen. Other considerations such as its high solubilities in fats and aqueous fluids may imply additional concerns which have not been brought to light, with risks that may not be warranted considering the degree of benefit.

TECH NOTE!!
Counterdiffusion is also a problem if a gas switch is made from argon to helium
(animal experiments by D'Aoust gave near fatal results - see Bennett and Elliott, 3rd Edition).

The research that has been conducted on argon as a diving gas has generally not been for decompression but for other purposes such as studying inert gas narcosis, respiration, or counterdiffusion.

Little research has been conducted on this gas in terms of providing safe and reliable decompression.

Article: *Deep Stops*

(The following article is presented as a means to explain Abysmal Diving's background thought on adding the Deep stop option to upcoming versions of Abyss.)

The Importance of Deep Safety Stops: Rethinking Ascent Patterns From Decompression Dives.
By Richard L. Pyle.

Before I begin, let's make something perfectly clear: I am a fish-nerd (i.e., an ichthyologist). For the purposes of this commentary, that means two things. First, it means that I have spent a lot of time underwater. Second, although I am I biologist and understand quite a bit about animal physiology, I am not an expert in decompression physiology. Keep these two things in mind when you read what I have to say.

Back before the concept of "technical diving" existed, I used to do more dives to depths of 180-220 fsw than I care to remember. Because of the tremendous sample size of dives, I eventually began to notice a few patterns. Quite frequently after these dives, I would feel some level of fatigue or malaise. It was clear that these post-dive symptoms had more to do with inert-gas loading than with physical exertion or thermal exposure, because the symptoms would generally be much more severe after spending less than an hour in the water for a 200-foot dive than they would after spending 4 to 6 hours at much shallower depths.

The interesting thing was that these symptoms were not terribly consistent. Sometimes I hardly felt any symptoms at all. At other times I would be so sleepy after a dive that I would find it difficult to stay awake on the drive home. I tried to correlate the severity of symptoms with a wide variety of factors, such as the magnitude of the exposure, the amount of extra time I spent on the 10-foot decompression stop, the strength of the current, the clarity of the water, water temperature, how much sleep I had the night before, level of dehydration ...you name it...but none of these obvious factors seemed to have anything to do with it. Finally I figured out what it was - fish! Yup, that's right...on dives when I collected fish, I had hardly any post-dive fatigue. On dives when I did not catch anything, the symptoms would tend to be quite strong. I was actually quite amazed by how consistent this correlation was.

The problem, though, was that it didn't make any sense. Why would these symptoms have anything to do with catching fish? In fact, I would expect more severe symptoms after fish-collecting dives because my level of exertion while on the bottom during those dives tended to be greater (chasing fish isn't always easy). There was one other difference, though. You see, most fishes have a gas-filled internal organ called a "swimbladder" - basically a fish buoyancy compensator. If a fish is brought straight to the surface from 200 feet, its swimbladder would expand to about seven times its original size and crush the other organs. Because I generally wanted to keep the fishes I collected alive, I would need to stop at some point during the ascent and temporarily insert a hypodermic needle into their swimbladders, venting off the excess gas. Typically, the depth at which I needed to do this was much deeper than my first required decompression stop. For example, on an average 200-foot dive, my first decompression stop would usually be somewhere in the neighborhood of 50 feet, but the depth I needed to stop for the fish would be around 125 feet. So, whenever I collected fish, my ascent profile would include an extra 2-3 minute stop much deeper than my first "required" decompression stop. Unfortunately, this didn't make any sense either. When you think only in terms of dissolved gas tensions in blood and tissues (as virtually all decompression algorithms in use today do), you would expect more decompression problems with the included deep stops because more time is spent at a greater depth.

As someone who tends to have more faith in what actually happens in the real world than what should happen according to the theoretical world, I decided to start including the deep stops on all of my decompression dives, whether or not I collected fish. Guess what? My symptoms of fatigue virtually disappeared altogether! It was nothing short of amazing! I mean I actually started getting some work done during the afternoons and evenings of days when I did a morning deep dive. I started telling people about my amazing discovery, but was invariably met with skepticism, and sometimes stern lectures from "experts" about how this must be wrong. "Obviously," they would tell me, "you should get out of deep water as quickly as possible to minimize additional gas loading." Not being a person who enjoys confrontation, I kept quiet about my practice of including these "deep decompression stops". As the years passed, I became more and more convinced of the value of these deep stops for reducing the probability of DCI. In all cases where I had some sort of post-dive symptoms, ranging from fatigue to shoulder pain to quadriplegia in one case, it was on a dive where I omitted the deep decompression stops.

As a scientist by profession, I feel a need to understand mechanisms underlying observed phenomena. Consequently, I was always bothered by the apparent paradox of my decompression profiles. Then I saw a presentation by Dr. David Yount at the 1989 meeting of the American Academy of Underwater Sciences (AAUS). For those of you who don't know who he is, Dr. Yount is a professor of physics at the University of Hawaii, and one of the creators of the "Varying-Permeability Model" (VPM) of decompression calculation. This model takes into account the presence of "micronuclei" (gas-phase bubbles in blood and tissues) and factors that cause these bubbles to grow or shrink during decompression. The upshot is that the VPM calls for initial decompression stops that are much deeper than those suggested by neo-Haldanian (i.e., "compartment-based") decompression models. It finally started to make sense to me. (For a good overview of the VPM, read Chapter 6 of Best Publishing's Hyperbaric Medicine and Physiology; Yount, 1988.)

Since you already know I am not an expert in diving physiology, let me explain what I believe is going on in terms that educated divers should be able to understand. First, most readers should be aware that intravascular bubbles are routinely detected after the majority of dives - even "no decompression" dives. The bubbles are there - they just don't always lead to DCI symptoms. Now; most deep decompression dives conducted by "technical" divers (as opposed to commercial or military divers) are very-much sub- saturation dives. In other words, they have relatively short bottom-times (I would consider 2 hours at 300 feet a "short" bottom time in this context). Depending on the depth and duration of the dive, and the mixtures used, there is usually a relatively long ascent "stretch" (or "pull") between the bottom and the first decompression stop as calculated by any theoretical compartment-based model. The shorter the bottom time, the greater this ascent stretch is. Conventional mentality holds that you should "get the hell out of deep water" as quickly as possible to minimize additional gas loading. Many people even believe that you should use faster ascent rates during the deeper portions of the ascent. The point is, divers are routinely making ascents with relatively dramatic drops in ambient pressure in relatively short periods of time - just so they can "get the hell out of deep water".

This, I believe, is where the problem is. Maybe it has to do with the time required for blood to pass all the way through a typical diver's circulatory system. Perhaps it has to do with tiny bubbles being formed as blood passes through valves in the heart, and growing large due to gas diffusion from the surrounding blood. Whatever the physiological basis, I believe that bubbles are being formed and/or are encouraged to grow in size during the initial non-stop ascent from depth. I've learned a lot about bubble physics over the last year, more than I want to relate here - I'll leave that for someone who really understands the subject. For now, suffice it to say that whether or not a bubble will shrink or grow depends on many complex factors, including the size of the bubble at any given moment. Smaller bubbles are more apt to shrink during decompression; larger bubbles are more apt to grow and possibly lead to DCI. Thus, to minimize the probability of DCI, it is important to keep the size of the bubbles small. Relatively rapid ascents from deep water to the first required decompression stop do not help to keep bubbles small! By slowing the initial ascent to the first decompression stop, (e.g., by the inclusion of one or more deep decompression stops), perhaps the bubbles are kept small enough that they continue to shrink during the remainder of the decompression stops.

If there is any truth to this, I suspect that the enormous variability in incidence of DCI has more to do with the pattern of ascent from the bottom to the first decompression stop, than it has to do with the remainder of the decompression profile. DCI is an extraordinarily complex phenomenon - more complex than even the most advanced diving physiologists have been able to elucidate. The unfortunate thing is that we will likely never understand it entirely, largely because our bodies are incredibly chaotic environments, and that level of chaos will hinder any attempts to make predictions about how to avoid DCI. But I think that we, as sub-saturation decompression divers, can significantly reduce the probability of getting bent if we alter the way we make our initial ascent from depth.

Some of you may now be thinking "But he said he's not an expert in diving physiology - why should I believe him?" If you are thinking this, then good - that's exactly what I want you to think because you shouldn't trust just me. So, why don't you dig up your September '95 issue of DeepTech (Issue 3) and read Bruce Weinke's article? I know it covers some pretty sophisticated stuff, but you should keep re- reading it until you do understand it. Why don't you call up aquaCorps and order audio tape number 9 ("Bubble Decompression Strategies") from the tek.95 conference, and listen to Eric Maiken explain a few things about gas physics that you probably didn't know before. While you're at it, why don't you order the audio tape from the "Understanding Trimix Tables" session at the recent tek.96 conference? You can listen to Andre Galerne (arguably the "father of trimix") talk about how the incidence of DCI was reduced dramatically when they included an extra deep decompression stop over and above what was required by the tables. On the same tape you can listen to Jean-Pierre Imbert of COMEX (the French commercial diving operation which conducts some of the world's deepest dives) talk about a whole new way of looking at decompression profiles which includes initial stops that are much deeper than what most tables call for. Why don't you ask George Irvine what he meant when he said he includes "three or four short deep stops into the plan prior to using the first stop recommended by each of the [decompression] programs" in the January, '96 issue of DeepTech (Issue 4)? If that's not enough, then check out Dr. Peter Bennett's editorial in the January/February 1996 Alert Diver magazine; he's talking about basically the same thing in the context of recreational diving. If you really want to read an eye-opening article, see if you can find the report on the habits of diving fishermen in the Torres Strait by LeMessurier and Hills (listed in the References section at the end of this article). The lists goes on and on. The point is, I don't seem to be the only one advocating deep decompression stops.

Are you still skeptical? Let me ask you this: Do you believe that so-called "safety stops" after so-called "no-decompression" dives are useful in reducing probability of DCI? If not, then you should take a look at the statistics compiled by Diver's Alert Network. If so, then you are already doing "deep stops" on your "no-decompression" dives. If it makes you feel better, then call the extra deep decompression stops "deep safety stops" which you do before you ascend to your first "required" decompression stop. Think about it this way: Your first "required" decompression stop is functionally equivalent to the surface on a dive that is taken to the absolute maximum limit of the "no-decompression" bottom time. Wouldn't you think that "safety stops" on "no-decompression" dives would be most important after a dive made all the way to the "no-decompression" limit?

Some of you may be thinking, "I already make safety stops on my decompression dives - I always stop 10 or 20 feet deeper than my first required stop." While this is a step in the right direction, it is not what I am talking about here. "Why not?", you ask, "I do my safety stops on no-decompression dives at 20 feet. Why shouldn't I do my deep safety stops 20 feet below my first required ceiling?" I'll tell you why - because the safety stops have to do with preventing bubble growth, and bubble growth is in part a function of a change in ambient pressure, not a function of linear feet. Suppose that, after a dive to 75 feet, you make a safety stop at 20 feet. Well, the ambient pressure at sea level is 1 ATA. The ambient pressure at 75 feet is about 3.3 ATA. The ambient pressure at your 20-foot safety stop is 1.6 ATA - which represents roughly the midpoint in pressure between 3.3 ATA and 1 ATA. Now, suppose you're on a dive to 200 feet (about 7 ATA) and your first required decompression stop is 50 feet (about 2.5 ATA). The ambient pressure midpoint between these two depths is 4.75 ATA, or a little less than 125 feet. Thus, on this dive you would want to make your deep safety stop at about 125 feet - exactly the depth I used to stop to stick a hypodermic needle in my little fishies.

But of course, the physics and physiology are much more complex than this. It may be that ambient pressure mid-points are not the ideal depth for safety-stops - in fact, I can tell you with near certainty that they are not. From what I understand of bubble-based decompression models, initial decompression stops should be a function of absolute ambient pressure changes, rather than proportional ambient pressure changes, and thus should be even deeper than the ambient pressure mid-point for most of our decompression dives. Unfortunately, I seriously doubt that decompression computers will begin incorporating bubble-based decompression algorithms, at least not in their complete form. Until then, we decompression divers need a simpler method - a rule of thumb to follow that doesn't require the processing power of an electronic computer. Perhaps the ideal method would be simply to slow down the ascent rate during the deep portion of the ascent. Unfortunately, this is rather difficult to do - especially in open water. Instead, I think you should include one or more discrete, short-duration stops to break up those long ascents. Whether or not it is physiologically correct, you should think of them as pit-stops to allow your body to "catch up" with the changing ambient pressure.

Here is my method for incorporating deep safety stops:

1) Calculate a decompression profile for the dive you wish to do, using whatever software you normally use.

2) Take the distance between the bottom portion of the dive (at the time you begin your ascent) and the first "required" decompression stop, and find the midpoint. You can use the ambient pressure midpoint if you want, but for most dives in the "technical" diving range, the linear distance midpoint will be close enough and is easier to calculate. This depth will be your first deep safety stop, and the stop should be about 2-3 minutes in duration.

3) Re-calculate the decompression profile by including the deep safety stop in the profile (most software will allow for multi-level profile calculations).

4) If the distance between your first deep safety stop and your first "required" stop is greater than 30 feet, then add a second deep safety stop at the midpoint between the first deep safety stop and the first required stop.

5) Repeat as necessary until there is less than 30 feet between your last deep safety stop and the first required safety stop.

For example, suppose you want to do a trimix dive to 300 feet, and your desktop software says that your first "required" decompression stop is 100 feet. You should recalculate the profile by adding short 2-minute) stops at 200 feet, 150 feet, and 125 feet. Of course, since your computer software assumes that you are still on-gassing during these stops, the rest of the calculated decompression time will be slightly longer than it would have been if you did not include the stops. However, in my experience and apparently in the experience of many others, the reduction in probability of DCI will far outweigh the costs of doing the extra hang time. In fact, I'd be willing to wager that the advantages of deep safety stops are so large that you could actually reduce the total decompression time (by doing shorter shallow stops) and still have a lower probability of getting bent - but until someone can provide more evidence to support that contention, you should definitely play it safe and do the extra decompression time. One final point. As anyone who reads my posts on the Internet diving forums already knows, I am a strong advocate of personal responsibility in diving. If you choose to follow my suggestions and include deep safety stops on your decompression dives, then that's swell. If you decide to continue following your computer-generated decompression profiles, that's fine too. But whatever you do, you are completely and entirely responsible for whatever happens to you underwater! You are a terrestrial mammal for crying out loud - you have no business going underwater in the first place. If you cannot accept the responsibility, then stay out of the water. If you get bent after a dive on which you have included deep safety stops by my suggested method, then it was your own fault for being stupid enough to listen to decompression advice from a fish nerd!

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Article: *Physiology and Physics of Helium*

Written by Robert Palmer, European Training Director, Technical Diving International

TISSUE SOLUBILITY

Helium enters tissues rapidly, up to 2.65 times faster than nitrogen, and leaves them more rapidly also. This requires the diver to use a different decompression profile with decompression stops starting deeper than for air, with short stops at depth to cope with the rapid onset of offgassing. Helium decompressions can be reduced by the use of nitrox at shallower depths, and can be further reduced by mixing helium with nitrogen to gain the best advantages of both gases where divers are shorter than about 2 hours.

MAIN EFFECTS OF HELIUM

The best known effect of helium is its distortion of speech. The thinner gas passing across the vocal cords at atmospheric pressure produces a comical high-pitched squeak reminiscent of Donald Duck and family. In fact, any change of air density can produce a similar effect - divers at a pressure of 4 bars in a recompression chamber (the equivalent of 30m while diving on air) will produce distorted speech also. Helium's speech distortion is only relevant when through-water communications are being used, and descramblers are commercially available to translate this distorted speech (usually unsuccessfully).

There is an apparent chilling during breathing. This is again due to the thinner molecular density of the gas, which transmits heat more readily by direct conduction that does air. The gas entering the diver's lungs will be colder than air, having lost heat during the journey from the cylinder via the regulator. However, the gas leaving the lungs will not conduct heat out of the body as readily as air, there being fewer molecules to warm up. Air by comparison is denser and may feel warmer when inhaled at any given depth, but will transmit more heat out from the lungs (and thereby contribute more significantly to core heat loss) than helium mixtures.

Where helium based mixtures do contribute significantly to heat loss is when they are used as drysuit inflation gases., but in general the use of trimix or heliox in drysuit inflation is to be avoided at all times.

High pressure nervous syndrome (HPNS) is possibly the most significant limitation to the use of helium as a diving gas, though the physiological process that creates this syndrome is currently still not entirely understood.

HPNS

High Pressure Nervous Syndrome is a physical manifestation of a high pressure gas gradient across tissue compartments, possibly compounded by helium breathing. It is exacerbated by rapid pressurization to depths of over 120 meters and appears at depths of between 120 and 200 meters (400-650'), depending on the speed of descent and, to a degree, the physiology of the diver. Some divers, for reasons not fully understood, appear to be more prone to HPNS than others.

The symptoms of HPNS include muscle tremors, drowsiness, loss of appetite, nausea, dizziness, vertigo, difficulty in concentrating, and visual disturbances, such as spots or patterns breaking up the diver's field of vision. Some of these symptoms are common to several forms of gas toxicity or physiological stressors (e.g. dizziness, nausea, loss of concentration) and could be confused with nitrogen or oxygen toxicity.

In commercial diving, the effects of HPNS are reduced by slow and staged pressurization, and by adding small amounts of nitrogen to "relax" tissues. Divers are pressurized to approximately 10-11 bars (90-100 meters) and held there for several hours for tissue saturation to take place, and the gas gradient to equilibrate. Pressurization is then resumed, and the dive halted again after a further increase in pressure, for the process to repeat itself. The transit to the "bottom" may thus take many hours, far longer than is possible on open or closed circuit SCUBA, with an attendant decompression lasting several days due to the complete saturation of the divers' tissues with the inert gas mixtures involved.

To reduce the effects of HPNS, small amounts of nitrogen may be used in the mixture to "relax" different tissues compartments and so reduce certain of the side effects, notably the muscle tremors that are typically the earliest and least controllable of the effects. The tremors are postulated to be caused by differential dissolution of gases into the tissues of the myelin sheath surrounding the nerves, causing the nerves to locally spasm.

At depths of up to 120 meters HPNS is unlikely to be a problem, though in general, the greater the depth, the more the chance of the syndrome appearing. On the rare occasions that open-circuit divers have descended to greater depths, trimixes containing between 7-11% of nitrogen are thought to have contributed to the partial controlling (though not the elimination) of HPNS.

GAS DENSITY

Helium's low molecular density has other practical advantages. The thinner molecular structure of helium-based mixtures produces a better regulator performance at depth by direct comparison with air. The reduced density also makes breathing easier, and may help to flush carbon dioxide out of the lungs. Carbon dioxide has been implicated in deep water blackouts, and an increased partial pressure of CO_2 is dangerous. High levels can be reached in the lungs with increasing depth, by improper breathing and increased gas density affecting regulator performance. Trimix can help reduce (but not eliminate) the problem.

OTHER INERT GASES

Helium, with the lowest lipid solubility has the lowest narcotic potential (paradoxically expressed as the highest relative narcotic potency (4.26). Xenon, which has the lowest narcotic potency figure (at 0.039) is actually an anaesthetic at atmospheric pressure, while krypton causes dizziness.

Hydrogen

Hydrogen has been used in extremely deep diving operations in excess of 500 msw (1600'), most successfully in association with helium to create hydroheliox. It has no benefit to open-circuit diving, being explosive when mixed with more than 5% oxygen. This would mean that a travel gas would be required to reach a depth at which 5% oxygen would support life, and then a flushing gas used to remove excess oxygen from the diver. At great depth, and when used with oxygen alone, hydrogen has narcotic effects more similar to similar to LSD, and has been implicated in long term psychological changes in saturation divers involved in some of the tests.

Neon

Neon has some advantages for short duration deep diving, but is too expensive to use as an open circuit breathing gas. It is a denser gas than helium and nitrogen, and diffuses more slowly into tissues than both gases, making it suitable for short deep bounce dives. However, it also emerges from tissues more slowly, and where long exposures are involves, decompressions can be excessive. Neox bends may also be more difficult to treat, involving complex recompression schedules.

Argon

Whilst almost twice as narcotic than nitrogen, it is also denser, and may have some application as a decompression gas. In theory, shallow stops could benefit from argox mixtures, reducing the amount of inert gas counterdiffusion into the tissues at depths over 9 meters, though this has had only limited testing, and cannot currently be recommended as a safe practice.

OXYGEN AND CO_2 NARCOSIS

There is some evidence to suggest that varying partial pressures of oxygen may affect narcosis, with higher partial pressures producing slight anaesthetic effects similar to narcosis.

Carbon dioxide retention may be involved in this, and undoubtedly higher levels of dissolved CO_2 in the blood due to CO_2 retention will affect the behavior of other dissolved gases to some degree. The relevance of CO_2 to technical diving is primarily to the effect of increased partial pressures of CO_2 causing depth blackout in association with increased workload at depth. The best way to avoid this is by breathing properly and pacing effort during the dive.

LONG TERM EFFECTS OF DEEP DIVING

There are several potential long term effects of deep diving of which the recreational or professional trimix diver should be aware. Many of these are still postulated, and remain formally unproven, but enough evidence exists to suggest that damage may be done to the diver's body by a variety of pressure-related processes.

Capillary Atrophication and Aseptic Bone Necrosis

Perhaps the best known of the long term problems is Aseptic Bone Necrosis, where the destruction of capillaries within bone tissues causes local necrosis of the bone - that is, the bone tissue effectively dies and falls apart. Traditionally, the long bones (thighs, shins, arms) were most at risk, with the heads of joints at shoulder and pelvis especially at risk. At one time this was though to occur primarily in commercial saturation divers, but it has been fairly commonly recorded in recreational divers, where there is some evidence to suggest that it affects the center sections of bones rather than the ends. What causes it is not entirely known, other than it is associated with capillary Atrophication. Such Atrophication may be associated with rapid pressurization and/or depressurization, where different tissues within the bloodstream on and offgas at different rates. This means that certain of the blood's constituent tissues may at different times during descent or ascent act as effective dams within the smallest capillary beds, creating tiny local embolisms or micro-Atrophication. Though this is perhaps most crucial in bones, capillary beds also exist in other vital areas of the body such as the brain, soft tissues such as the liver, kidneys, eyes, etc. At present, alterations to capillary bed structure in these other tissues are best described as "change" rather than damage, until more research is done on both cause and effect.

Research on Aseptic Bone Necrosis shows that affects approximately 5% of divers (both recreational and commercial) to some degree or another. Deep mixed gas diving may be one contributory factor, as may rapid pressurization/ depressurization, but the increase in symptoms evinced in recreational divers who do not undertake such practices suggests that the problem still warrants further research before too many conclusions can be drawn.

BUBBLE FORMATION

Micro-bubbles forming during decompression, though not creating any formal symptoms of decompression illness, may result in long term CNS damage to the spinal cord. Postmortems in divers who have not reported any symptoms of DCI during life have still been found to have significant damage to the spinal cord and central nervous system.

Those who have had formal decompression events may have significantly greater long term problems, especially divers who have suffered multiple type II bends.

Such "invisible damage" may or may not be associated with deep diving. It is possible that now out-dated diving practices may have contributed to these (e.g. faster ascent rates) and that individual physiology may also play a part. To a degree, all life activity, above or below water, contributes to the eventual long term decay of the body, and the older we get the more damage has been picked up along the way. It is possible to overreact to physiological "possibilities", and it must also be remembered that diving of any sort has a very low incidence of long term serious physiological damage per individual diver when compared with other activities.

However, when formal damage does occur it should be treated seriously. Getting decompression illness may result in small localized damage or it may contribute to longer term damage, such as possible brain lesions, which may in turn create later problems from reduced mental or physical function to premature senility. Divers of all sorts, and mixed gas divers in particular, should be aware of current research in diving medicine, and should keep themselves up to date with changes in our knowledge and understanding of diving medicine.

LIMITS

The practical depth limits of mixed gas open circuit diving, taking into account the physiological and environmental limitations of the activity, lie within the following boundaries.

- Cold water (below 20^0C) : 75-80 meters. (240-260')
- Warm water (over 20^0C) : 100-120 meters. (330-400')

The planning and execution of safe dives to these depths requires considerable knowledge and experience beyond that of the ordinary recreational SCUBA diver, and safe diving to depths in excess of these generally requires one atmosphere systems or saturation diving techniques, with all the massive attendant expense. While the occasional dive on open or closed circuit SCUBA to depths in excess of 120 meters does take place, the individual undertaking it has usually undergone considerable preparation, training and acclimatization, and has considerable support, or is simply very stupid.

Article: *Planning Gas Mixtures*

Written by Robert Palmer, European Training Director, Technical Diving International

INTERMEDIATE MIXES

Deep trimix dives require the use of multiple gas mixtures, and generally use a nitrox travel gas containing between 21 and 36 percent oxygen for use during the period from leaving surface to changing to bottom mix. There are two reasons for this. The first, and physiologically most important, is that many "bottom mixes" (as the trimix is often called) do not contain sufficient oxygen to be capable of supporting consciousness at the surface. Any mixture containing less than 16% oxygen falls into this category. Additionally, oxygen lean mixtures do not provide the best decompression schedules, and one or more oxygen rich mixtures are usually employed to ensure an acceptable decompression regime.

Travel Mixes

Travel mixes usually contain between 21 and 40% oxygen, with a nitrogen balance. Richer nitrox mixtures do not allow a convenient depth range, and weaker mixes offer no advantage. The depth at which the switch to trimix is undertaken depends on the PPO2 of the travel gas. A diver on EAN40 must switch by 30m (95'), at which point the PPO2 is 1.6 bars, whilst a diver on air can switch at depths of up to 60m (200'), at which point the PPO2 is at its maximum recommended limit, and the narcotic effect of the gas is becoming cause for concern. The richer travel mixtures allow a more effective decompression, and limit ongassing of nitrogen to a small degree during the initial descent. The weaker mixtures allow some room for safer bailout from bottom mix at greater depths, though offer a less effective decompression schedule than their richer counterparts. In most cases, a compromise is reached, and EAN32 or 36 are used for travel gases, allowing some room for deep bailout, and a slightly improved decompression schedule.

Decompression Gas

The gases used for the final stages of decompression usually contain oxygen percentages in excess of 50%. Pure oxygen can be used, but only for the final stops above six meters, unless a full face mask is used or special supervisory practices are employed. *We do not recommend that pure oxygen is used below 6 meters (20') for in water decompression unless in an emergency.* Mixtures containing 60 to 80% oxygen are most commonly employed, ensuring that the inert gas gradient is appropriately steep without creating the danger of oxygen toxicity in the final stages of the dive, when CNS percentage loading is at its greatest. The richer the mixture, then the better is the offgassing at the shallowest stops. However, weaker mixtures such as EAN50 or 60 allow the offgassing process to begin more effectively at slightly deeper stops, and allow a deeper changeover to the decompression mixture if the travel mixture is unavailable for any reason (e.g. equipment failure). This may be even more appropriate where very weak oxygen mixtures are used for the bottom gas (e.g. less than 12% oxygen). The choice of both travel and decompression gases should take into account possible bailout scenarios and the final CNS percentage dose, as well as the most appropriate decompression schedules.

SELECTING A TRIMIX

Before choosing your gas mixtures for a mixed gas dive, you need to know :

- *You should not exceed a PPO2 of 1.4 bars.*

Each gas mixture should maintain a PPO2 of 1.4 bars or less for the working portion of the dive. EAN mixtures reaching 1.6 bars PPO2 can be used during the decompression phase as long as the total oxygen CNS percentage does not exceed 100% at the end of the dive.

- *Your required Equivalent Narcotic Depth (END).*

Once you have your required END, the gas mixture to be used can be selected in association with the 1.4 bar oxygen limit.

- *The depth at which you will operate, and the time you wish to spend there.*

This will govern both the final selection of bottom mix and the amount of gas that must be carried to maintain a credible reserve.

Finding Your Equivalent Narcotic Depth.

Your END is the comparative depth on air at which you are entirely in control of narcosis, even under stress. You find the partial pressure of nitrogen at this depth by using the Dalton's Law formula : $PPN_2 = FN_2 \times P$. For example, an END of 35 meters would give a PPN_2 of : 0.79 x 4.5 = 3.55 bar.

THE "IDEAL MIX" CONCEPT

Custom mixes can be blended to generate the best trimix for a particular depth/duration. This is a mix which optimizes both oxygen and nitrogen levels to control the effects of both gases. Most trimix divers use a PPO_2 of 1.4 bars and an END of 40 - 50 meters.

How to Find the "Ideal Mix"

Use Dalton's Law formulae to first find the appropriate oxygen and nitrogen percentages, knowing your depth and the partial pressure of nitrogen of your required Equivalent Narcotic Depth. The balance is helium.

BLENDING TRIMIX

Firstly, do be aware that the actual blending of gases should only be done by divers or technicians who have successfully completed a recognized training course in that discipline. Not all EAN facilities or filling stations will encounter a need to blend trimix. Trimix, as its name suggests, is a blend of three gases, in this case oxygen, nitrogen and helium. Trimix is used to dive to depths greater than those encountered in recreational sport diving, most usually in the 40-100m range (130-330 feet). The use of helium reduces both the effects of oxygen toxicity and nitrogen narcosis, but requires considerable additional training and experience on the part of the diver, well in excess of that required for the safe use on EAN mixtures.

There are several ways in which trimix may be produced. A diver may prefer to use one of the standard, or may select to use what is referred to as an "ideal mix", where the partial pressures (and thus percentages) of oxygen and nitrogen are preselected according to the precise depth of the dive. Alternatively, a third option of "heliair" exists, where the diver may accept a slightly higher than normal equivalent narcotic depth to enable the simplest form of production of trimix by adding air to helium.

SELECTING A TRIMIX

A diver planning a trimix dive will generally select a trimix that gives an oxygen partial pressure of 1.4 bar (ata) and a nitrogen partial pressure of 4 to 5 bar (ata) at the deepest point of the dive. This allows a maximum oxygen exposure of up to 150 minutes, and an equivalent narcotic depth (END) of 40 meters (130') to 50 meters (160'), which means that the diver would suffer no more nitrogen narcosis during the dive than on air at those depths. Where a specific rather than a generic mix is used, this would be termed the Ideal Mix for that dive.

To produce the appropriate trimix, all the blender needs to know is the depth of the planned dive and the partial pressures of oxygen and nitrogen required. The depth of the dive will give the absolute pressure in bar or atmospheres, and the proportions of the constituent gases can be worked out and related to the pressure of the cylinders to be used.

REAL AND IDEAL GAS LAWS.

The actual compressibility of gas is related to several things. The main ones are :

- The molecular density of the gas.
- The temperature of the gas.
- The pressure to which the gas is being compressed.

Most mixing calculations work with what are termed *Ideal Gas Laws.* These assume that all gases have the same molecular density and react in the same way to temperature and pressure. Thus if temperature is kept constant, mixing oxygen, nitrogen and helium would be a simple and predictable process.

In reality, though oxygen and nitrogen have similar molecular densities, helium is considerably less dense than either. *Real Gas Laws* take such variations in compressibility and molecular density into account. Helium, being the least dense of the three gases, is the most compressible at higher pressures. The higher the pressure, the greater the variation in actual gas percentage content of the mixture. For example, if 100 bar of oxygen and 100 bar of helium were compressed together at the same temperature, the resulting mix would contain about 54% oxygen and 46% helium. We tend therefore, when dealing with trimix percentages, to round oxygen down to the nearest whole percent and helium up.

In actual fact, minor variations in compressibility, temperature, gauge accuracy and analyzer accuracy during the actual blending process all tend to even the process out. To compute for Real Gas Laws that take into account the variations in compressibility due to molecular density and the temperature generated by an actual on site mixing system requires equations that can only reliably be done by computer, and a very slow blending process to keep temperatures constant. While such computer programs exist, and are available to the Gas Blender, the final variation in analyzed trimix blended using Ideal rather than Real Gas Laws is, in real life, virtually indistinguishable from blends made from Real Gas Laws. The difference is far more in the quality and skill of the actual blender.

BLENDING TRIMIX IN THE CYLINDER

There is a standard procedure for blending trimix, taking into account the different properties (and costs) of the component gases. It is usual to place helium (the most expensive gas) in first. Oxygen (if required) is then added, both gases being decanted slowly, with intervals in between to allow temperature to be as constant and stable as possible. Once both helium and oxygen are in, it is possible to analyze the resulting mix to ensure that the correct percentage of oxygen (as a proportion of the 2 gases) is present.

The table at the end of this chapter is used for blending trimix into empty cylinders. It assumes that 1 bar of existing gas is already in the cylinder. The gas makeup of the 1 bar of gas in the cylinder (as long as it is air or trimix) will not materially affect the final balance of the new mixture. (Remember, in a 210 bar / 3000 psi cylinder, 1 bar of gas = 0.5% and 1 psi = 0.03% of the gas in the cylinder.) A the maximum depth given for the above mixtures, the PPO_2 is approx. 1.4 bar and the Equivalent Narcotic Depth is approximately 40m / 130'.

Once this has been done, and the mixture is analyzed as acceptable, air should be added vigorously to encourage mixing. The tank should be laid on its side during this process, as the less dense helium will tend to layer out unless agitated. Often the tank is rolled from side to side while being filled, or immediately following filling, to ensure mixing is adequate. The cylinder should be allowed to stand till cool, at which point it should be analyzed for oxygen percentage. If the mix is too rich, more air can be added. Too low, and oxygen can be added with a booster pump if required.

Once mixed, the gases will stay mixed due to the constant movement of the gas molecules ("Brownian Motion"). It is still good practice to re-analyze trimix immediately before the dive to ensure the original analysis was correct.

If the oxygen percentage is within 1 percent, it is assumed the nitrogen and helium percentages are also accurate. In practice, a percentage variation of 3-4 percent in these inert gases will not compromise decompression requirements or nitrogen toxicity, and it is unlikely that, if the oxygen is within 1% of calculated value, that the inert gas percentages will be much adrift.

HELIAIR

A simpler blending process is to mix helium and air directly to produce a trimix commonly called Heliair, or occasionally “Poor Man’s Mix”. The latter is somewhat of a misnomer, as the expensive component is actually the helium, and heliair sometimes requires more rather than less of the gas. For the blender, the problems are less, with only two gas mixtures being used, but the diver must be competent enough to accept the higher PPN_2 (and thus END) that goes with the mixture to ensure that the PPO_2 does not exceed critical levels. Heliair is generally used more in tropical waters, where the environmental contribution to stress and narcosis is reduced to a more manageable level.

HELIUM SAFETY

Pure helium should never be breathed during the blending process, or at any other time. Irreversible asphyxiation may occur as a result of the rapid diffusion of the gas into the lung tissues, essentially blocking the passage of oxygen once the helium source is removed. Diving grade helium generally contains about 2% oxygen (which also allows it to be breathed from directly at saturation depths in emergency) and this helps maintain a conduit for oxygen. Be especially aware of children using trimix or helium cylinders to fill balloons unsupervised, or using it to make funny voices. Balloon grade helium contains between 20-30% oxygen to prevent asphyxiation, and this makes it unsuitable for diving purposes. Do not allow diving grade, or any other grade, of helium to be used for balloon filling or for play.

TRIMIX CYLINDERS

Trimix cylinders need not be oxygen service unless pure oxygen is used in the blending process. Where the cylinder is simply used for heliair (helium/air mixtures) or where helium is blended with the appropriate EAN mix produced from a continuous blending system, an ordinary air cylinder will suffice. If oxygen is used in the blending process, the cylinder should be in oxygen service. In either case, the cylinder should be labeled TRIMIX in large letters, and have a label on it indicating the relative percentages of the mixtures in the cylinder and its maximum depth. Several training agencies market Trimix stickers for cylinders, usually in a red color.

REQUIRED CYLINDER PRESSURE (PSI / BAR)

	O_2HeN_2 Mix	1.4 bar O_2 depth	1500psi	2000psi	3000psi	4000psi	150 bar	210 bar	230 bar	300 bar
H	18/14/68	220’/60m	210	286	429	571	29	30	32	42
E	17/19/64	240’/75m	285	381	571	762	30	40	44	57
L	16/24/60	260’/80m	360	476	714	952	36	50	56	72
I	15/28/57	280’/85m	470	571	857	1143	42	60	65	84
A	14/33/53	300’/90m	495	667	1000	1333	50	70	77	99
I	13/38/49	320’/100	570	762	1143	1524	57	80	88	114
R	12/43/45	340’105m	645	857	1286	1714	65	90	100	129

This chart give the pressure of helium to add to an empty cylinder to produce the desired heliair mixture. Select the cylinder pressure in psi or bar from the top row, and move down that column until the required mix is reached. All these mixes have an END of 55m (180’)

Article: *Dive and Decompression Planning*

Written by Robert Palmer, European Training Director, Technical Diving International

TRIMIX OPERATIONS

Trimix dives are formal operations. Treat them as such, and plan them meticulously, or don't do them. The exposures you place yourself in are dangerous and extreme, and the room for error is virtually non-existent. You may die at any time on any technical dive. And YOU don't have to weep at your grave.

TEAMS

Select the appropriate team size (this may even be a team of one if redundancy levels are appropriate and the environment so dictates). Don't make the team too big, or too small. Make the team experienced, well-equipped, well-prepared and psychologically and physically stable. If boat diving, the skipper is part of the team. Brief him/her thoroughly. He or she may well not be familiar with some of the practices concerned, and may not therefore respond appropriately to incidents.

BEFORE THE DIVE

Review all plans. Check all equipment. Set all lines and decompression materials. Spend some time in mental preparation. Don't dive till everyone and everything is ready. It really isn't worth adding more stress than is necessary to a deep mixed gas dive. Do make sure that more than enough time is allowed before the dive for preparation.

ENTERING THE WATER

Carry all your gases in a logical order, with the richest mixture on the right. Know where they are, and which regulator goes with which gauge. Once having entered the water, make sure your equipment is still in the same place it was before. Never simply assume it will be where it was before you jumped in and rearranged it!. Check you can read all gauges and reach all valves and regulators and their essential equipment. Check you can reach your cylinder vales in an emergency.

Acclimatize at the surface or at 6 meters if the surface is choppy. Take time to orientate yourself to boat or shore, currents and bottom. Thorough buddy check - leaks and gear. Take a definite time check before starting your actual descent, and note your start time on your slate.

DESCENT

Stick as closely as possible to planned descent times - extra minutes on descent can mean extra hours on decompression, or lost minutes on the bottom. Control your buoyancy AT ALL TIMES. If you lose control of your buoyancy it can affect both your descent rate and your breathing rate, and add a source of stress to the dive.

Be prepared for gas switches before you need to make them. Make them on the move if possible, and practice to ensure a smooth and effective switch. Stow used regulators properly, and remember to turn off travel gases at depth to avoid toxicity problems. Slow your descent with your BC or drysuit just before you reach the bottom, and hover just above it, to maintain visibility.

ON THE BOTTOM

Plan your dive to the Rule of Thirds. Be precise. Take everything slowly - don't rush. Maintain proper buoyancy. Keep stress to a minimum. Always be aware of your location. Don't exceed planned depths or times for any reason.

ASCENT

Stick to the set ascent times for your dive. The ascent period is actually your fist phase of decompression, and these times are planned into your schedule. Travel at 20 meters/minute (60'/minute) to the first stop or the nitrox switch, whichever comes first. This reverses the gas gradient more effectively. From that point, travel at 10 meters/minute (30'/minute) between stops - this controls the ascent and reduces bubble formation during offgassing.

If a gas switch and a decompression stop coincide, take a moment to adjust your buoyancy before making the switch. A loss of buoyancy supervision can result in an unplanned ascent or descent of several meters if you are not careful.

This section applies Te**chnical Nitrox Mixed Gas and Adv. Mixed Gas** users only.

DECOMPRESSION STRATEGIES

Avoid free-floating decompressions unless currents or tides dictate it. If the currents are weak, use decompression stations hung below the support vessel, with enough room at each station for the number of divers it is designed to support. Use standby divers to monitor the progress of the decompressing divers at a regular interval, and establish some method of emergency communication (e.g., slate and line) that allows rapid communication with the surface at all times. Emergency decompression cylinders should be in the water close to the divers, and these should have been placed, along with the decompression station, before the start of the dive. Wherever you can, stay as a group. If you must free-float, then a group of divers linked together is a manageable unit at all times. Several pairs of individuals floating off in subtly different directions over a one or two hour period is a recipe for disaster. Do ensure a support craft (small inflatable) travels above the group, containing back-up cylinders and a standby diver. Make the whole decompression as trauma free as possible.

ORAL REHYDRATION

It is possible to supply decompressing divers with fluids, and rehydration should be a priority on long decompressions, especially in tropical countries. Any form of collapsible container is suitable, and if proprietary brands are not available, then the lining of cardboard wine containers will do nicely. Isotonic sport drinks such as Sport Lucozade or Gatorade can be obtained in collapsible card containers, and straws can be used effectively underwater. Remember that it takes about 6 hours to properly orally rehydrate a dehydrated diver, and a fairly continuous supply of fluid, even water, is better than vast amounts before and after a dive.

DECOMPRESSION HINTS

Full face masks may be used to maintain warmth and may reduce the potential for CNS oxygen toxicity, though proper oxygen management is more effective. It is quite possible, with prior practice, to change to a FFM underwater, and the real value of doing so is that of oral communication and warmth. Be prepared for a FFM to use much more gas than predicted by open-circuit RMV calculations, and practice beforehand to establish required gas volumes. On long decompressions, it may be more appropriate to run either pure oxygen or EAN 60-80 from the surface on a long umbilical hose, either to a second stage regulator or a FFM. The length of hose required will not materially affect the delivery of gas to a depth of 6 meters from a modern regulator. This allows an uninterrupted supply of gas without too many unwieldy cylinders taking up space in the water. If this is done, however, a bailout cylinder should be kept on standby in the water to cover any interruption in the supply.

PURE OXYGEN

Undertaking the shallowest stops on pure oxygen offers the most effective offgassing gradient. However, on a long decompression the 6 meter stop may deliver over 50% of the maximum recommended CNS percentage limits, and it is recommended that pure oxygen not be used at depths exceeding 3 meters. Even a medium swell may provide pulses of increased partial pressure, and the whole toxicity tracking process becomes less predictable. Even in an emergency, it is unsafe to switch to pure oxygen below 10 meters, even if this requires breathing the bottom mix to an extremely shallow depth. As long as the PPO2 of the inspired gas is above 19%, symptoms of hypoxia are unlikely to occur. The use of slightly weaker nitrox decompression mixtures (e.g.. 50-80% oxygen) offers some extra breathing depth in such an emergency, and is to be recommended. This does not preclude the use of pure oxygen for the 3 meter stop as a safety measure. Pure oxygen should obviously be available on the surface for emergency use, and an adapter which allows an oxygen clean SCUBA regulator to be fitted directly to a large oxygen cylinder, medical and non-medical, is a distinct advantage.

SURFACING

The last few meters actually cover the greatest pressure change, and are perhaps one of the most crucial point of the ascent. It is no coincidence that most cases of decompression illness occur just after the diver surfaces. Anything that can be done at this time to reduce the potential for bubble formation should be done. Some things you can do to help this process are :

1. Take two minutes to ascend the last 6 meters. **2. Rest on the surface for 5 minutes**
3. Dekit in the water - with assistance! **4. Rest on the boat / shore for at least 10 minutes before any action. Then rest some more.**
5. Try and avoid undue effort at all stages of the surfacing, getting out of the water, and dekitting process. Remember that helium bubbles are present, and more will offgas very readily if you give them the slightest provocation!

Abyss Index