USER'S MANUAL

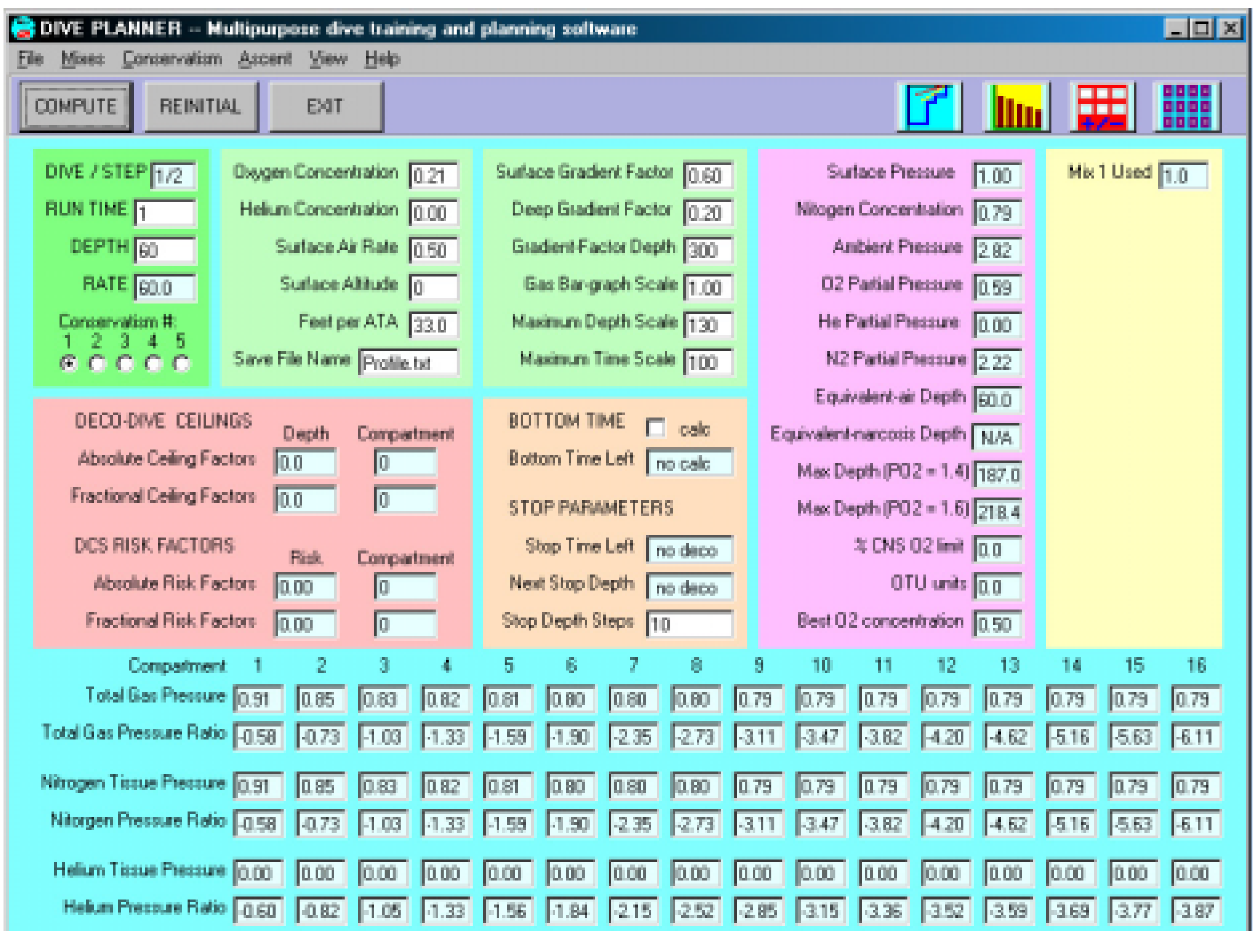
by

CASUARINA AQUATICS, INC.

CASUARINA DIVE PLANNER

Casuarina Dive Planner™ software is a product of Casuarina Aquatics, Inc.™ It is intended for dive planning by properly certified divers or for training of appropriately trained divers by properly certified instructors. Hence it can be utilized by a wide range of divers. Casuarina Dive Planner can be used for planning non-decompression dives within standard sport-diving limits by "recreational" divers; it can be used by divemasters and specialty divers to develop understanding of inert-gas dynamics and established models for DCS and oxygen-related phenomena; and it can be used by “technical” divers for planning multi-level, mixed-gas dives.

Casuarina Dive Planner uses well-established algorithms for all calculations, and has a user-friendly interface that provides easy text inputs, point-and-click selections, and simple text and graphical outputs.



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9. **General**. You agree that any and all claims against ***CAI*** not effectively released or waived by the foregoing will be brought in the state or federal courts located in the Southern District of New York, and that any such claim will be brought within one year of the date the incident or accident leading to such claim occurred, and that no action in any forum or jurisdiction may be made or maintained after such one-year anniversary.

   These terms constitute a contract between you and ***CAI***, and can be modified only by a written agreement signed by both parties. If any part thereof is determined to be void or unenforceable, the remaining provisions shall remain in effect. These terms shall be governed by and construed in accordance with the laws of the State of New York as applied to contracts made and wholly performed within that State.

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Casuarina Dive Planner (***CDP***) software by Casuarina Aquatics, Inc., (***CAI***) is licensed for use by the purchaser ("you") under the terms of the License Agreement above. The following terms are a part of that License. You must read the License Agreement and the following terms carefully before using ***CDP***. ***CDP*** is to be used for (1) planning recreational scuba dives by appropriately trained and certified divers; (2) training recreational scuba divers by appropriately trained and certified instructors; and (3) knowledge development by recreational divers in training under the supervision of an appropriately trained and certified instructor.

By using ***CDP***, you acknowledge and agree that:

Your Training and Skill. You will use ***CDP*** software in the voluntary, recreational activity of scuba diving, and only if you have successfully completed training and certification in a diving course providing sufficient training for the type of diving you are planning by using ***CDP***. The ***CDP*** user's manual is NOT a substitute for adequate, proper training and certification. You are fully aware of the inherent risks and dangers of scuba diving in general, and the risks of decompression diving in particular, and understand that serious personal injury or death may result at any time on any scuba dive.

Scuba Diving Risks Generally. Scuba diving takes place in a hostile environment. It has certain inherent dangers and risks which can never be completely eliminated. By scuba diving and using ***CDP***, you voluntarily choose to encounter and assume any and all such risks and dangers. Good training, good equipment, and the proper safety-conscious attitude can minimize the risks of diving, but cannot eliminate the risks of serious personal injury or death. Serious personal injury or death may result on ANY scuba dive, even if all recognized safe diving procedures are followed and the diver performs every dive according to accepted diving practice.

Use of Casuarina Dive Planner. You will read and follow all warnings and instructions for the use of the ***CDP*** software found in the owner's manual. While use of ***CDP*** software or any other computer-based decompression program can enhance the diving experience, unavoidable risks and dangers exist when conducting a scuba dive with planned decompression stops. Among the many risks you assume when using ***CDP*** software are the risks of decompression sickness (DCS) and central nervous system (CNS) oxygen toxicity. Even if you follow all the warnings and instructions, and even if you follow safe diving practices, DCS or CNS oxygen toxicity might occur on any given dive, causing serious personal injury or death. You must be trained and prepared for these risks.

Informed and Voluntary Acceptance of Responsibility. You ultimately are responsible for your own safety while diving. By using ***CDP*** software, you acknowledge that you understand and accept that responsibility.

INSTALLATION

CDP is distributed on CD ROM and diskette media, and through web downloads. The distributed files include full Windows installation functions that utilize standard installation procedures. The ***CDP*** executable files are installed in a default "Dive Planner" subfolder within your computer's "Program Files" folder. This User's Manual is included as an Adobe Acrobat file that you either can view on your monitor or print.

Installation can be performed directly from CD ROM and diskette media. Installation from a download requires you to place the installation files in a temporary folder, then run the installation from that folder. In any of the installation modes, you will need to enter the **serial number** assigned to your software; installation will abort if you do not provide the serial number.

During installation, the installation software will give you an **installation code** (different from the serial number) that you must record and e-mail, fax, or postal mail to ***CAI***. In return, ***CAI*** will provide you with an **activation key** to complete your installation. If you do not have and enter the activation key before 10 days after installation, ***CDP*** will not run.

If you wish to transfer your ***CDP*** to a different computer than the computer used for its initial installation, you will have to uninstall ***CDP*** using ***CDP***'s uninstall software – not the Windows "remove software" function – and obtain an **uninstall code**. You will need to e-mail, fax, or postal mail that uninstall code, the serial number, and the new installation code to ***CAI*** to activate ***CDP*** on the new computer.

CDP is ordinarily sold under a single-user license agreement. (See the details in the Legal Issues section.) If you wish to install ***CDP*** on more than one computer, you may purchase ***CDP*** under a cost-effective, multiple-user license. Please contact ***CAI*** by e-mail, fax, or postal mail for further information on multiple-user licenses.

You must register your copy of ***CDP*** immediately upon installation. You can register using the form on the ***CAI*** web site, by e-mail, by fax, or by postal mail. Your registration information must include: the ***CDP*** **serial number** and **installation code**; and your name, address, and contact information. Registration entitles you to free enhancement upgrades and reduced-cost new versions. Upon registration, ***CAI*** will provide you with an **activation key** for fully enabling ***CDP***. Registration is important if you later move ***CDP*** from one computer to another. It will enable ***CAI*** to validate that transfer using your registered serial number, old and new installation codes and uninstall code, and will authorize ***CAI*** to provide you with a **new activation key** for re-enabling ***CDP*** on the new computer.

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OVERVIEW

CDP is a program intended to help properly trained divers learn about diving physiology, gain an improved understanding of the reasons behind good diving practice (e.g., prudent bottom times, slow ascents, mixed-gas use, decompression profiles, etc.), and to plan safe dives across a broad spectrum of diving rigor (e.g., from entry-level recreational dives to extreme technical dives). Naturally, ***CDP*** must be used in a manner that is consistent with the diver's level of training and certification, and in most cases, it will be of greater interest and value to the more-advanced diver, but as long as it is used in a manner consistent with a diver's training and certification, it can serve a variety of diver needs. Beginners can gain insight into gas-related phenomena underlying their dive tables and planners, while more-advanced divers can develop safe profiles for extreme decompression diving that takes into account gas consumption, oxygen effects, and narcosis risks while allowing the individual diver to apply conservatism in a variety of ways and iteratively to develop an optimal plan that satisfies that diver's needs and constraints.

One of ***CDP***'s most significant features is its simple, easy-to-use graphical user interface (GUI) that presents all important information on a single main screen with auxillary displays on separate screens. On high-resolution displays, all screens can be viewed simultaneously. On low-resolution displays, auxilliary screens can be displayed at any time by clicking on a menu, an icon, or a task-bar entry.

CDP provides the diver with standard defaults for many variables, such as gas composition (air), altitude (sea level), water type (salt), etc. The diver can begin panning by entering non-default values, initializing ***CDP***, then entering waypoint information, i.e., depth and runtime, for each step in the dive. ***CDP*** then returns outputs of a variety of kinds for the latest waypoint based on the entire dive profile up to the waypoint, and tracks all waypoints in a plot of depth and ceilings vs. time and in a text file that can be used subsequently to document and execute the selected dive plan.

The algorithms underlying ***CDP***'s computations, its inputs and its outputs are described in the sections that follow. However, knowing that most of us are in a hurry to get started, a quick-start guide is provided first. Hopefully, this Manual will enable you to use ***CDP*** in with ease; the sections after the quick-start introduction section are intended to describe the use of ***CDP*** in sufficient depth to make its use straightforward and productive. Questions on the use of ***CDP*** that remain after you read this Manual can be submitted to ***CAI*** by e-mail, fax, or postal mail.

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STEP-BY-STEP QUICK-START GUIDE

This is a quick-start guide to using ***CDP***. It introduces some of the basic techniques. It is not a complete presentation of ***CDP***'s features. These are presented in other sections of this manual. It is not a substitute for proper training. You must have proper training or be under the supervision of a properly trained instructor in order to use this software. ***CDP is intended only for use by properly trained divers for planning and executing dives.***

Units are decimal US and British, e.g., feet, ATA (or bar), minutes (to hundredths of a minute – not seconds), etc.

1. Set up the variables by clicking on the INITIAL command button in the upper left of the form. Before you click INITIAL, the available command buttons are INITIAL and EXIT. After you click on INITIAL, the command-button set will change to COMPUTE, REINITIAL, and EXIT.

2. Verify that all input variables, e.g., O_2 and He concentration, altitude, planned dive depth, shallow and deep gradient factors, etc., are properly entered before the computation for the first step of the dive.

3. Enter the depth and run time for the first STEP (or "waypoint") of the dive – typically, this will be a descent to 130 feet or less. (The background of "rate" text box becomes yellow if a descent rate exceeds 66 feet/minute. It becomes red if the run time is not incremented.) See step 8 below if the planned depth exceeds 130 feet. Note that you don't enter a depth of 100 and time of 20 for a 20 minute dive to 100 feet; for each STEP, you enter the depth reached at the end of the STEP and you enter the total run time from the very beginning of the computations to the end of that STEP.

4. After a successful computation, the command-button set changes to show ACCEPT, RECOMP, REINITIAL, and EXIT.

5. If the displayed results are satisfactory, e.g., acceptable ceilings or risks are computed and no errors in entries are observed, then click ACCEPT. Note that once you click ACCEPT, you cannot correct prior computations. After clicking ACCEPT, you can correct an error only by clicking on REINITIAL and starting over.

6. If the displayed results are not satisfactory, and if you have not yet clicked ACCEPT, then you can correct or change your entries by clicking RECOMP and changing entries until the desired results are generated. This might occur if your computation resulted in an unacceptable fractional ceiling for decompression or if you found you could extend bottom time and still have a favorable ceiling. In other words, you can adjust entries iteratively to optimize the result in terms of your dive objectives. Note that these results can be optimized in terms of a variety of displayed parameters, e.g., oxygen partial pressure, nitrogen partial pressure, CNS exposure, degree of decompression risk, ceilings for decompression stops, etc. See step 7.

7. When you click ACCEPT, three additional outputs are generated: 1) a bar graph, called "Gas Content by Compartment," that shows the gas content (N_2 and He) in each of the compartments (along with absolute M values in red and fractional M values in yellow); 2) a line chart, called "Depth and Ceilings vs. Time," that shows the depth profile in blue, the absolute ceiling in red, and the fractional ceiling in yellow; and 3) a record, i.e., a line of text in a separate file called "Profile.txt" (or other name you designate at initialization, as mentioned in item 8), which lists several dive parameters for the corresponding profile point (e.g., run time depth, ceilings, gas-mix variables, gas consumption, etc.). If the bar graph and dive-profile charts are minimized or become hidden by the main form, they can be viewed by clicking on their form's icon at the top of the main window or in the task bar at the bottom of the screen.

8. When you click on INITIAL, you can enter an alternative output text file name or an alternative maximum depth and profile run time (for the profile plot). The defaults are "Profile.txt" for the file name, 130 feet for maximum depth, and 100 minutes for maximum time.

9. At any time, you can change a variety of other variables, such as: 1) O_2 and He concentrations (N_2 concentration is calculated automatically); 2) altitude (at the surface, which also can apply to driving or flying after diving), and 3) fractions of the difference between ambient pressure and M-value pressure at the surface and at depth, i.e., the so-called "Gradient Factor" (GF). The default depth for the deep fraction is 300 feet; it can be changed and always should equal or exceed the maximum planned dive depth. These changes only affect computations made <u>after</u> the changes are entered.

10. The main window allows access to calculators for manually computing: 1) run time for an ascent at 33 feet per minute to an entered depth, and 2) run time after adding the entered run-time increment (or STEP time) to the current run time. (The default depth for the ascent calculator is the fractional ceiling if it is deeper than 15 feet; otherwise it is 15 feet.) Access is gained by clicking on the calculator icon at the top of the main window or selecting the calculator in the view menu.

11. A separate form, called "Compartment Parameters," shows the Beuhlman parameters, i.e., half-times, M-value slopes and M-value intercepts upon which all dissolved-gas computations are based. They can be changed at any time for custom calculations (by clicking the form's icon at the top of the main window or in the task bar), but the default values always will be reentered when the program starts. An example of a situation in which you might change values would be if you substitute H_2 for He.

12. To estimate no-decompression-limits (NDLs), the recommended procedure is to enter a descent time of 0.01 minutes (the minimum run-time increment the program will allow), for STEP 1; then enter and compute or recompute the run time to find the maximum that results in an absolute ceiling of 0; the NDL is the maximum time that allows a 0 value for the absolute ceiling (e.g., 17.9 or 18 minutes at 100 feet and 53.9 or 54 minutes at 60 feet). For repetitive diving, the adjusted no-decompression limit is calculated in the same manner after a surface interval; the surface interval is simply time spent at a depth of zero feet. (Note that either air or oxygen-enriched air could be used during the surface interval. Enriched air will decrease a required surface interval or extend the adjusted no-

decompression limit, but at the surface, enriched air with an O_2 concentration of more than 50%, i.e., a PO_2 of more than 0.50, will increase CNS exposure and OTU accumulation, while any surface gas mix with an O_2 concentration of 21% or less will reduce CNS exposure with a half time of 90 minutes without changing OTU accumulation.)

13. Computations for a decompression dive would take place in the following steps; each step is computed by clicking COMPUTE (or RECOMPUTE after a correction or iterative change) and recorded by clicking ACCEPT:

    a. Enter the appropriate values or verify the default values of surface and deep gradient factors, depth for the deep gradient factor, gas graph scale (to optimize the display), and maximum planned depth and time (for the profile graph).

    b. Enter appropriate new values or verify that the default values of gas concentrations for the first travel (descent) mix are correct, e.g., the default values of 0.21 for O_2 and 0.00 for He in air or 0.32 and 0.00 for EAN/32.

    c. Enter the run time and the depth at which the change to a second mix will occur if a mix change is planned, e.g., a change from air to tri-mix.

    d. Repeat step 13c until the bottom is reached. Verify that the gas concentrations in the working mix are correct. Enter the run time for the fixed or work bottom depth (or the first bottom depth if a multi-level dive is planned).

    e. Repeat step 13d as appropriate for a single- or multi-level dive. Adjust the run time to the last working depth to allow the fractional ceiling depth to be slightly shallower than the planned first decompression stop, e.g., 97 or 98 feet for a 100-foot stop.

    f. Use the STOP-TIME CALCULATOR to determine the run time to the planned decompression stop depth (at an ascent rate of 33 feet per minute or less.) (Note that decompression stops typically are made at multiples of 10 feet, except that some experts recommend the shallowest stop be at 20 feet. See step 13h below.)

    g. Enter the run time and depth for the first decompression stop. Remain at the stop depth until the fractional ceiling is safely above (shallower than) the next planned decompression stop depth, which usually is 10 feet shallower. (Note that an ascent time of 0.5 minutes (30 seconds) for a 10-foot ascent corresponds to a safe ascent rate of 20 feet per minute.)

    h. Repeat step 13g using a convenient mix nearest the optimal mix shown in the BEST mix text box. A switch to air from tri-mix can help purge He while maintaining an adequate partial pressure of O_2, and a switch to EAN/32 or other nitrox mix during ascent can help purge N_2 as well as He. EAN/80 is commonly used at a stop depth of 20 feet. The 10-foot stop often is replaced by a longer 20-foot stop on EAN/80 to minimize effects of waves on depth control.

i. Complete the dive using one minute to ascend from 20 feet to the surface. Switch to air (especially if EAN/80 is used at the 20-foot stop) to reduce CNS exposure.

j. A surface interval may be followed by a subsequent dive or by an ascent to altitude (in an automobile or airplane).

If limits in PO_2 (maximum of 1.6 or 1.4 ATA or minimum of 0.16 ATA are reached, a message box will appear and will give a warning; text box colors change to red. A similar warning occurs when PN_2 plus PO_2 is greater than 6.0, i.e., equivalent to an air depth of 165 feet. (You also can note the equivalent air or narcosis depth boxes to observe the approach to this limit.)

You can monitor the profile depths and the gas contents of each compartment by clicking on the appropriate display button in the task bar. The gas contents also are shown numerically in the text boxes at the bottom of the main form. (A green background in a text box indicates a compartment pressure greater than ambient pressure; a yellow background indicates a compartment pressure greater than 50% of the difference between ambient pressure and the M-value pressure, and a moderately risky situation re DCS; a red background indicates a compartment pressure greater than the M-value pressure, and an extremely dangerous situation in terms of DCS risk.)

14. Upon completion of an acceptable profile (i.e., one that achieves the desired bottom-time objectives while minimizing ascent (decompression) time by optimizing stop times and ascent mixes), you can read and print the parameters of the dive that were entered into Profile.txt (or an alternative file that you name at the time of initialization). The large number of columns in the file are printed best if you use a landscape mode, select a font size of 8, and set the margins no more than 0.5 inches. You also can import this text file into Excel or other spreadsheet as a tab- or space-delimited text file, and through the spreadsheet you can plot various parameters contained in the file (in addition to ceilings and depths). Examples are risk factors, gas concentrations, etc.

DESCRIPTION OF THE SOFTWARE

The Casuarina Dive Planner (***CDP***) software is described here in terms of its underlying algorithms, its inputs, its outputs, and its tools. This description is not intended to substitute for proper training. If you encounter terms you do not understand, be alert to the possibility that your training may be insufficient for safe use of this product for dive planning.

ALGORITHMS

The core of ***CDP*** is the Beuhlman decompression model described in numerous publications. (See for example, John Lippman, *Deeper Into Diving*, pp 247-278, J. L. Publications, Victoria, Australia, 1991.) ***CDP*** incorporates the most recent and conservative of the Beuhlman models. The model used in ***CDP*** incorporates 16 compartments for nitrogen (N_2) and helium (He) with halftimes ranging from 4.00 to 640 minutes for N_2 and from 1.51 to 240 minutes for He. (The exact values for all compartments are shown in ***CDP***'s Compartment Parameters table.)

As described in the literature, the Beuhlman model is Haldanian in that it assumes that tissues can tolerate a gas overpressure in each compartment and that the tolerated overpressure is proportional to ambient pressure. The overpressure is termed the M-value, and it is higher for compartments with lower half times, i.e., “faster” tissues. The relationship between M-value and ambient pressure is a simple linear one where the M-value equals some “intercept” value (value at zero absolute pressure) plus a proportionality constant (called the “slope”) times the ambient pressure. This can be expressed by the equation below

$$M = M_0 + (m * P_A)$$

where M is the M-value, M_0 is the M-value at zero absolute pressure (“intercept”), m is the proportionality constant (“slope”), * is the symbol for multiplication, and P_A is the ambient pressure. The conventional practice in no-decompression diving is to limit the bottom time so that no compartment pressure exceeds its M-value upon surfacing.

An interesting feature of this kind of formulation is that it lends itself easily to altitude diving. In fact, the anecdotes say that the need for tables applicable to diving in the high-altitude lakes of Switzerland was part of Beuhlman’s motivation to develop this model.

Decompression diving imposes added risk and warrants added conservatism. Conservatism can be applied in many ways, e.g., by reducing the intercept or slope values that define the M-values. A commonly used alternative method is to leave the slope and intercept unaltered, but to limit tissue pressures to some portion or fraction of the difference between ambient pressure and M-value pressure. Common terminology calls the difference the “gradient” and the fraction the “gradient factor.” ***CDP*** employs a means of specifying the gradient factor at depth (300’) and at the surface. The gradient factor changes linearly with depth between its surface and deep values. As described in sections below, the user can override all the default settings for the gradient factors, and also can impose additional conservatism. The user must employ judgment in cases where stressful diving conditions are anticipated, e.g., cold or arduous dives, and should increase conservatism accordingly.

The reduction in N_2 concentration that occurs when diving with nitrox or enriched air nitrox (EANx) reduces the partial pressure of N_2 at any depth. This reduced nitrogen partial pressure is equivalent to the N_2 partial pressure in air at a shallower depth. When only nitrogen and oxygen are used in the breathing gas, ***CDP*** expresses the depth at which the partial pressure of N_2 in air equals that of the EANx being used as equivalent air depth or "EAD."

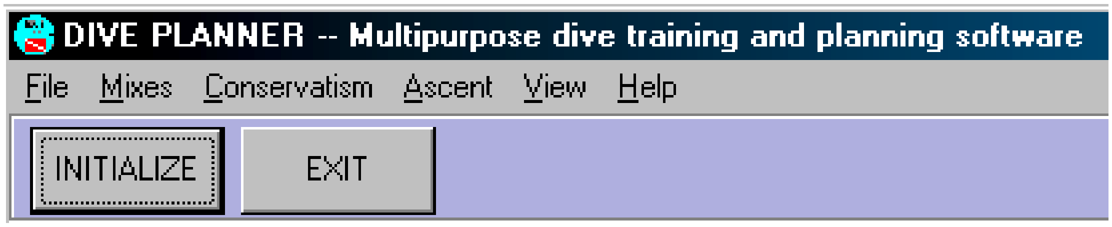
Diving at depths of 100' or more imposes risks of narcosis. Mixed gases replace O_2 and N_2 of air with other gases, typically He. When He is used, narcosis potential is reduced, and ***CDP*** uses simple algorithms to express that potential as an equivalent narcosis depth or "END" if air were the actual mix. Incidentally, ***CDP** considers O_2 and N_2 to be equally narcotic!*

Diving at depth subjects the diver to elevated partial pressures of O_2; this exposure is particularly relevant when EAN is the breathing mixture. Oxygen partial pressure (PO_2) in excess of 0.50 ATA are considered to increase the risk of acute and chronic oxygen-toxicity reactions. ***CDP*** uses standard algorithms to express oxygen-exposure factors in terms of the % of allowable oxygen exposure for acute oxygen toxicity associated with central nervous system (CNS) responses to high-pressure exposures, and in terms of oxygen-tolerance units (OTUs) associated with pulmonary responses to long-term exposures. These algorithms provide results identical to those presented in NOAA tables of oxygen exposure limits. (See various editions of the *NOAA Diving Manual*, U.S. Department of Commerce, Government Printing Office.) CNS exposure decreases with a half-time of 90 minutes when PO_2 is equal to or less than 0.21. OTU values do not increase when PO_2 is less than 0.50, but remain constant and rely upon the diver to utilize published tables of OTU limits to asses risk. The OTU concept originally was developed by Dr. Bill Hamilton, he established limits for various exposure durations to limit pulmonary risks. The table below summarizes those OTU limits. (Under most recreational technical-dive conditions, OTU limits are very unlikely to be approached.)

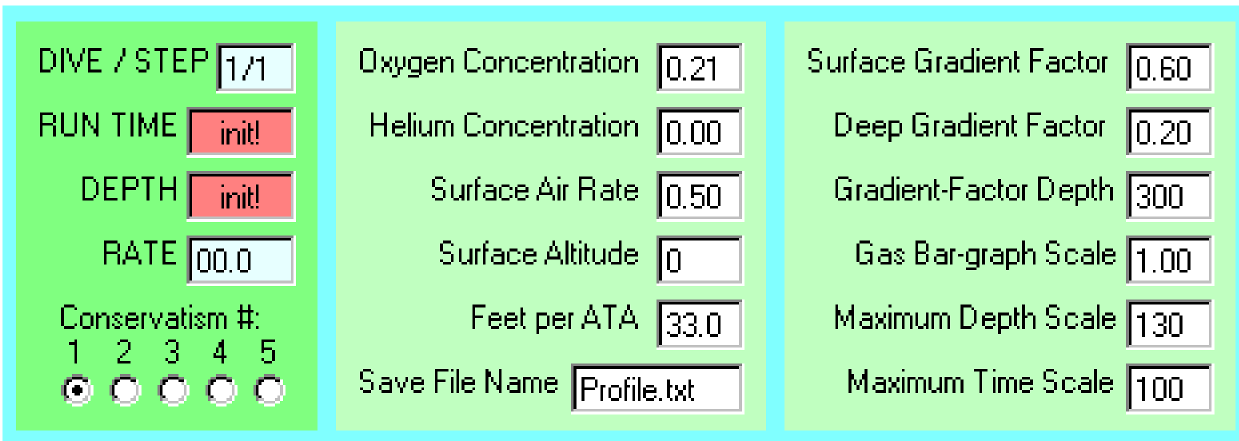
DAYS	OTU limit
1	850
2	1400
3	1860
4	2100
5	2300
6	2420
7	2660
8	2800
9	2970
10	3100

CDP also includes simple algorithms to compute the volume(s) of breathing gas(es) consumed during the dive based on a reference surface "air-consumption" rate (SAR) and the ambient pressure. The user can increase the SAC if cold or arduous conditions are anticipated.

INPUTS

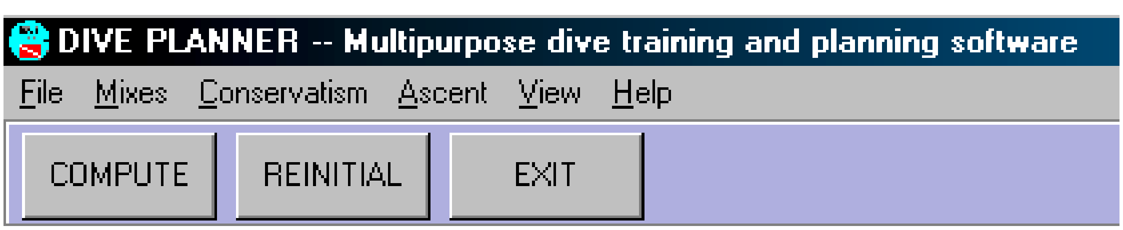


Before ***CDP*** runs, you must initialize it by clicking on the INITIALIZE button at the upper left of the ***CDP*** graphical user interface (GUI).

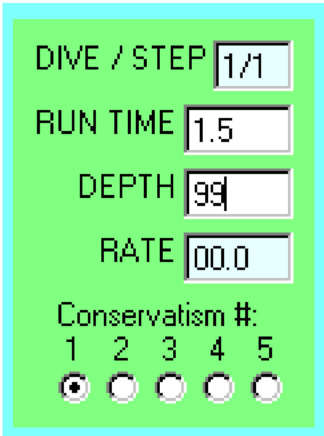


The main inputs for ***CDP*** are located in frames with green backgrounds. Any box with a white background can accept an input; boxes with shaded backgrounds display outputs.

You most-often will make inputs using the dark-green frame at the upper left of ***CDP***'s graphical user interface (GUI). Inputs for each waypoint are entered in the RUNTIME and DEPTH boxes; you must enter a new time to define a new waypoint; however, depth can remain unchanged. Each new runtime must be at least 0.01 minutes longer than the previous runtime. The runtime is the time from the start of the profile. The shaded boxes (which do not accept inputs) in this frame show the present dive NUMBER and STEP of the present dive in the DIVE / STEP box and the descent rate in the RATE box. (A positive rate indicates a descent and negative rate indicates an ascent.) You can select an added margin of safety by selecting a CONSERVATISM option; each increment of increasing conservatism reduces each of the 16 Beuhlman intercept values by an added 5%; the reduced intercept values affect all decompression-related calculations, including ceilings, no-decompression limits, stop times, etc.



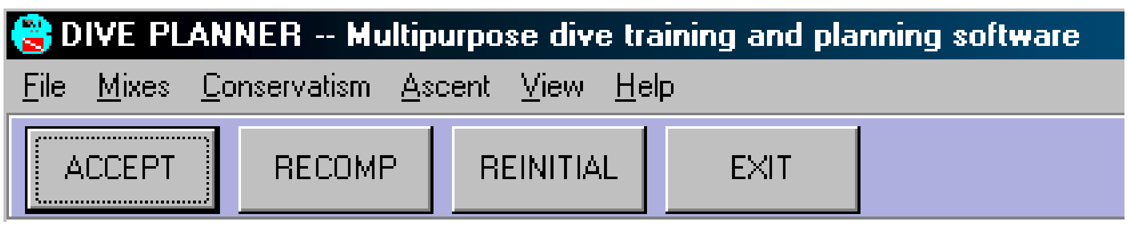
After initialization, you can enter your inputs for RUNTIME and DEPTH, and can have ***CDP*** compute the parameters for the waypoint just entered by clicking on the COMPUTE button. Sample inputs for a descent to 99’ in 1.5 minutes are shown below. The command button set changes to display COMPUTE, REINITIAL, and EXIT



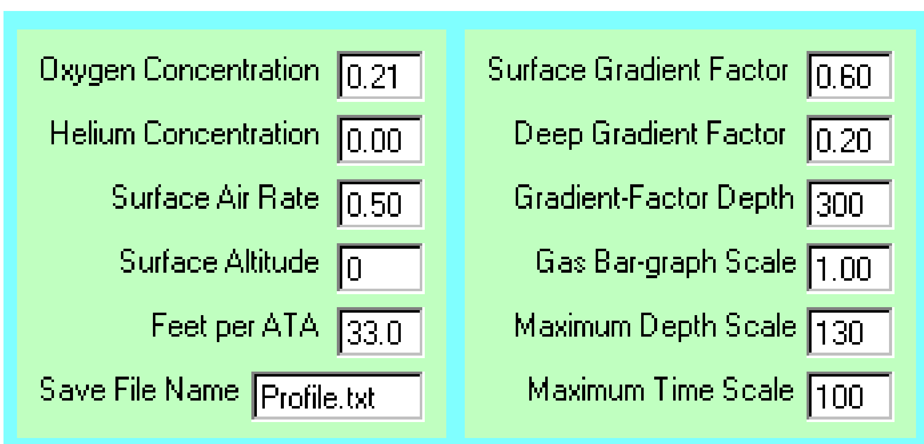
Note that in this example, the default conservatism is selected.

After you click on the COMPUTE button, the command buttons change to ACCEPT, RECOMP, REINITIAL, and EXIT. If the computation is satisfactory, click ACCEPT. Once you click ACCEPT, you cannot recompute any steps, but before you click ACCEPT, you can change the last waypoint inputs – runtime and depth – or other inputs, and can recompute by clicking on RECOMP. If you need to make a correction after clicking ACCEPT, your only recourse is clicking REINITIAL, which wipes the slate clean.

An example of the RECOMP button set is shown below.



The lighter green frames include numerous additional input options. Any of them can be changed at any waypoint, and the changes will affect all subsequent computations, including recomputations at a given waypoint.



The default O_2 concentration is 0.21 and the default He concentration is 0.00, which corresponds to air. (***CDP*** automatically computes N_2 concentration as the difference between 1.00 and the sum of O_2 and He concentrations.)

The Surface Air Rate (SAC) is the rate of gas consumption referred to the surface. Most divers have an estimate of their surface rate of air consumption, and it typically is between 0.40 and

1.00 cubic feet per minute. The default of 0.50 cubic feet per minute is representative of an experienced fit diver under low-stress conditions. The SAC can and should be increased for higher stress dives (cold or arduous), but a higher SAC only increases computed gas-consumption results; *it does not affect decompression considerations.* To take higher stress into account for decompression-related calculations, you must increase conservatism or the decrease the gradient factors discussed below.

The Surface Altitude can represent the actual altitude of the water surface during a dive or the altitude of a diver at a depth of 0 feet while flying or driving to an altitude different from the dive altitude. The default is 0, which corresponds to sea level.

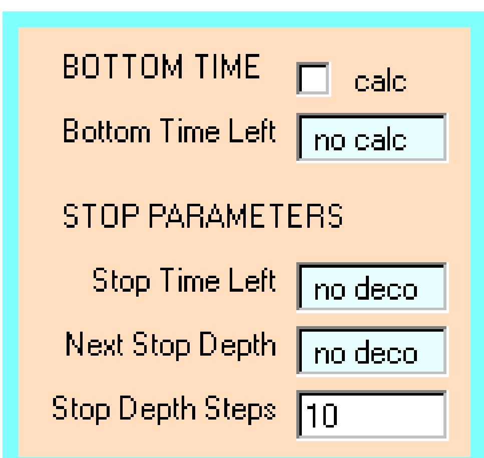
Feet per ATA depends on water density. The default value of 33 corresponds to salt water; the fresh water value is 34. Other values may be used for different water salinities.

Waypoint parameters and computed results are saved in an ASCII text file. The Save File Name entry enables you to set the name of the file prior to initializing or reinitializing ***CDP***. Results of every accepted computation are entered into this file. The default name is Profile.txt.

As mentioned in the prior discussion of the basic algorithms used in ***CDP***, “gradient factors” provide a means of imposing conservatism with respect to decompression. Increasing the a gradient factor value decreases conservatism; decreasing it increases conservatism. Gradient factors are set at the surface and at depth. The default Surface Gradient Factor is 0.60, and the default Deep Gradient Factor is 0.20. The default Gradient Factor Depth is 300’ and the gradient factor remains the same at greater depths than the Gradient Factor Depth.

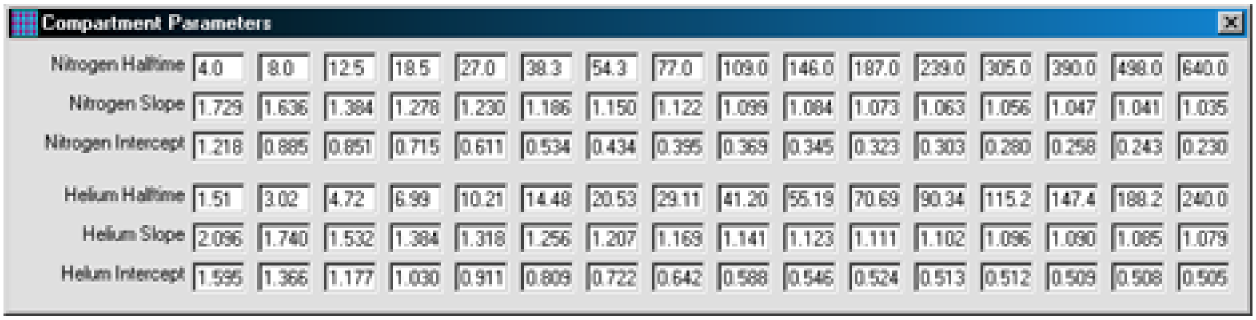
The Gas Bar Graph Scale controls the vertical scaling of the bar graph that displays the gas content in each of the 16 Beuhlman compartments. The bar graph changes immediately when the scale is changed. This bar graph is described below under **Graphical Outputs**.

The Maximum Depth Scale and Maximum Time Scale control the scaling of axes on the dive profile plot that displays the depth, absolute ceiling, and fractional ceiling at every waypoint. This profile plot is described below under **Graphical Outputs**.



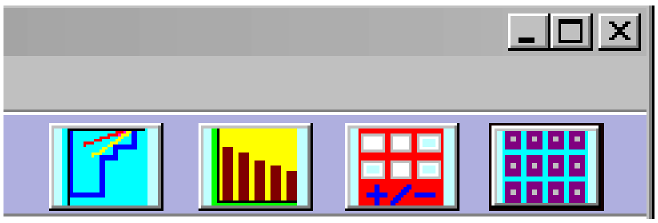
Two other minor inputs are the check box for calculating the remaining no-decompression bottom time and the text box for specifying the depth increment between decompression stops. Calculations of remaining no-decompression time can be quite time consuming under some circumstances, so the default is not to calculate. The 10’ default stop-depth increment is commonly used because it theoretically minimizes the ascent and decompression time and simultaneously minimizes the risk of ascending above a ceiling.

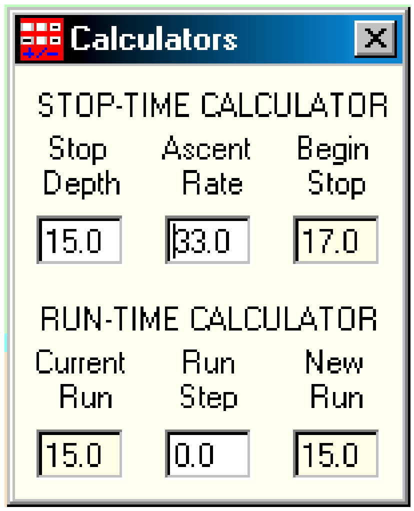
A rarely used optional input is the table of Beuhlman M-value parameters, half times and the slope and intercept values for 16 the N_2 and He compartments used in decompression-related calculations. This table can be changed to incorporate alternative values for various reasons. For example, the He values might be changed to values for an alternative inert gas, such as H_2 or neon were used to replace N_2. Changing the values in this table should be done only by divers with advanced technical diving certifications and a thorough understanding of the physiological implications and consequences of such changes.


Compartment Parameters

Nitrogen Halftime	4.0	8.0	12.5	18.5	27.0	38.3	54.3	77.0	109.0	146.0	187.0	239.0	305.0	390.0	498.0	640.0
Nitrogen Slope	1.729	1.636	1.384	1.278	1.230	1.186	1.150	1.122	1.099	1.084	1.073	1.063	1.056	1.047	1.041	1.035
Nitrogen Intercept	1.218	0.885	0.851	0.715	0.611	0.534	0.434	0.395	0.369	0.345	0.323	0.303	0.280	0.258	0.243	0.230
Helium Halftime	1.51	3.02	4.72	6.99	10.21	14.48	20.53	29.11	41.20	55.19	70.69	90.34	115.2	147.4	188.2	240.0
Helium Slope	2.096	1.740	1.532	1.384	1.318	1.256	1.207	1.169	1.141	1.123	1.111	1.102	1.096	1.090	1.085	1.079
Helium Intercept	1.595	1.366	1.177	1.030	0.911	0.809	0.722	0.642	0.588	0.546	0.524	0.513	0.512	0.509	0.508	0.505

This table is accessed by clicking its icon in the upper right of the ***CDP*** GUI. The adjacent icon selects a simple calculator that you can use to calculate the run time to the next stop from an entered ascent rate and stop depth. You also can use it to calculate the run time to the next waypoint from the current runtime and a step time, i.e., time to the next waypoint.

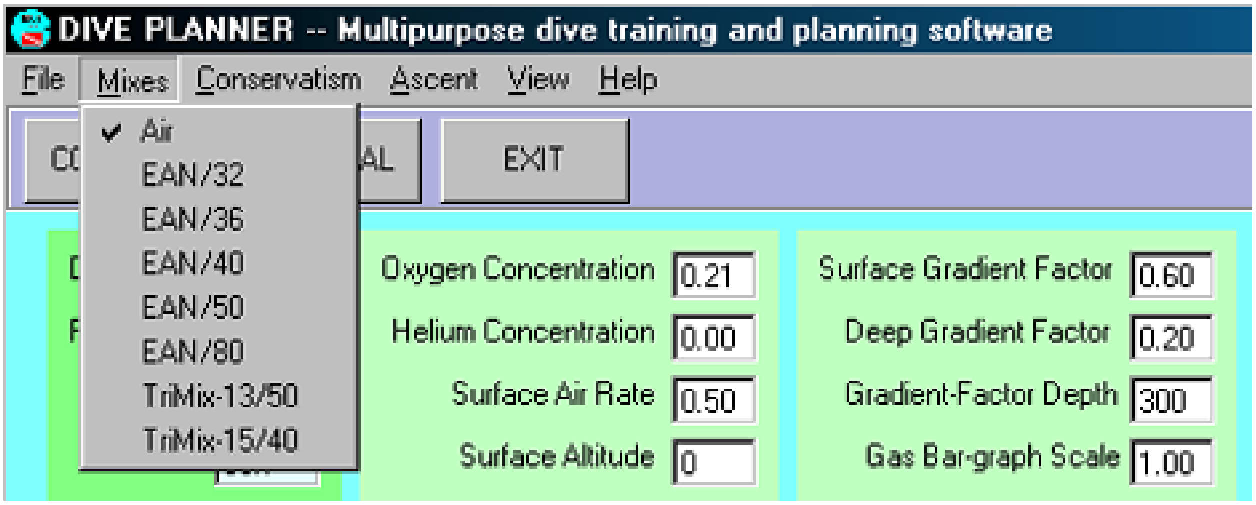




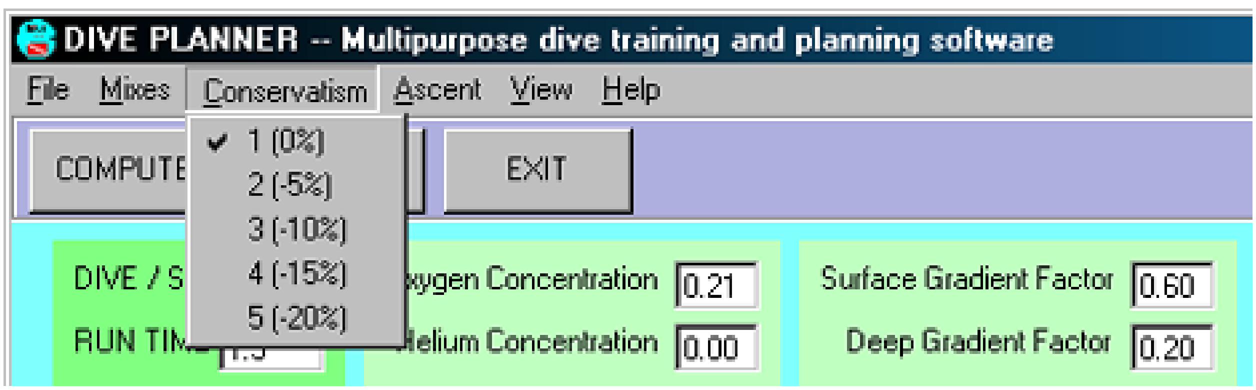
MENUS

CDP offers several menus. Some are basic, standard menus; others are unique to ***CDP***. The menus that are unique to ***CDP*** are described here.

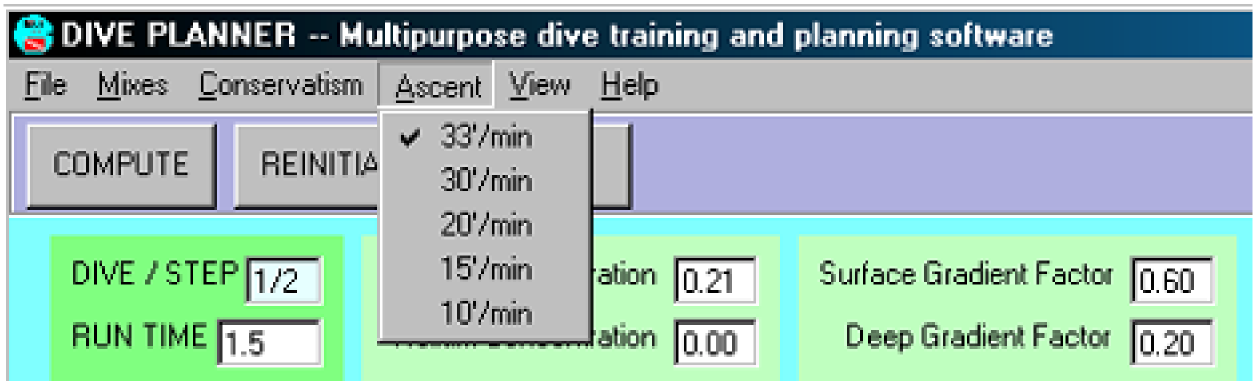
The Mixes menu shows several standard mixes. It provides an alternative means of entering mix information and reduces the chance of error in inserting a mix. (Advise ***CAI*** if you think additional commonly used mixes should be included in this menu.)



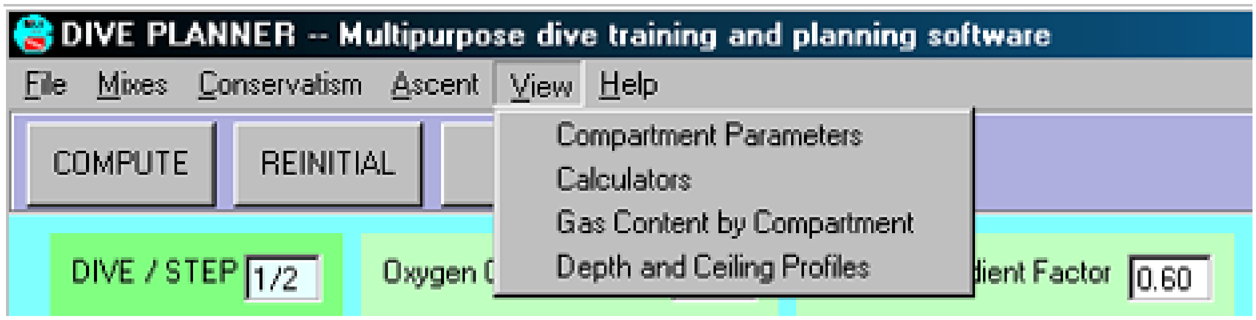
The Conservatism menu presents the 5 optional degrees of conservatism. It provides an alternative manner of entering different degrees of conservatism, and it is explicit about the % change each option produces.



The Ascent menu presents several different ascent rates for use in the Calculator. It offers an alternative means of specifying ascent rates. The diver can enter a higher ascent rate at depth and lower ascent rates as the surface is approached.

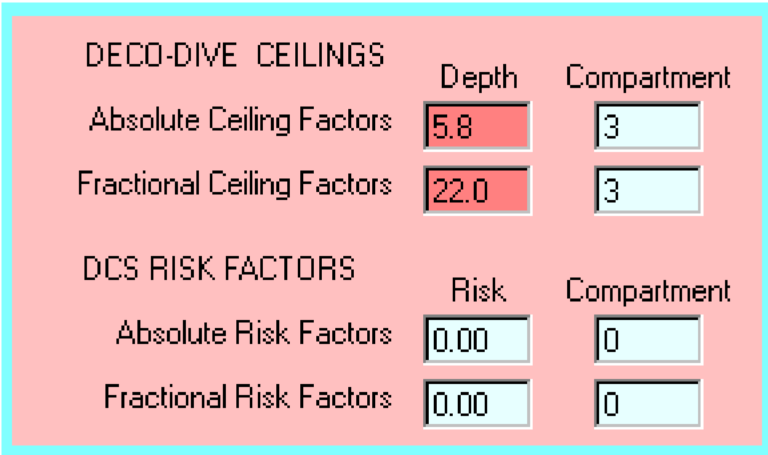


The View menu presents options for graphical outputs. It duplicates the functions of the icons at the upper right of the ***CDP*** GUI. Note that these viewing functions only are required on computers with monitors that display 800 x 600 pixels or less. All graphical outputs can be made simultaneously visible on larger displays.

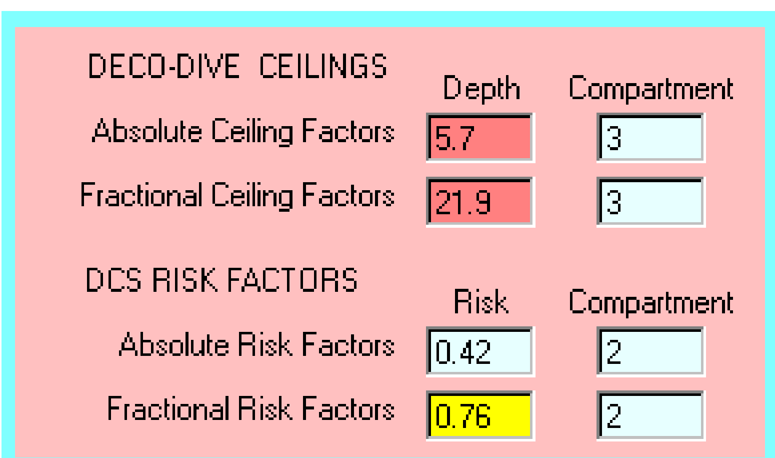


TEXTUAL OUTPUTS

CDP offers numerous outputs in a text form. (These are supplemented in graphical form, as described in the next section.)



The most-frequently used outputs are likely to be the DECO DIVE CEILINGS: the Absolute and Fractional Ceiling Factors displayed in the orange frame. When the absolute ceiling is not zero at a waypoint, then at least one M-value would be exceeded after a 33'/minute ascent to the surface. Therefore, a non-zero absolute ceiling at depth establishes that the dive is a decompression dive and requires decompression stops. For a decompression dive, the fractional ceiling indicates the <u>minimum</u> depth for the first decompression stop. In the example at the left, a stop at or deeper than 22' is prescribed; ordinarily, a 22' fractional ceiling would warrant a stop at 30'. However, the dive profile can be adjusted set so that the fractional ceiling is slightly shallower than a depth that is a multiple of 10', e.g., in the present example, bottom time could have been extended to give a 28' ceiling for a 30' stop. The Absolute and Fractional Ceiling Factors also display the compartment numbers that establish the two ceilings. In the present examples, both ceilings are established by conditions in compartment 3. Note that the no-decompression limit for a dive can be established by increasing the bottom time iteratively until a non-zero absolute ceiling appears. The absolute ceiling depends upon the conservatism factors entered by the diver. The fractional ceiling is dependent upon the surface and deep gradient factors as well as the conservatism factors entered by the diver.



DCS RISK FACTORS are displayed upon ascent. The Absolute Risk Factors for DCS show 1) the degree to which tissue gas pressure in the compartment that is most-loaded relative to the M-value approaches the M-value, and 2) compartment number of the compartment with the greatest M-factor gas load. The Fractional Risk Factors show 1) the degree to which tissue gas pressure in the compartment that is most-loaded relative to the gradient factor approaches the gradient-factor limit, and 2) the number of the compartment with the greatest gradient-factor gas load. In both cases, red indicates the limit is exceeded and risk is assigned a value greater than 1.00; yellow indicates a risk between 0.50 and

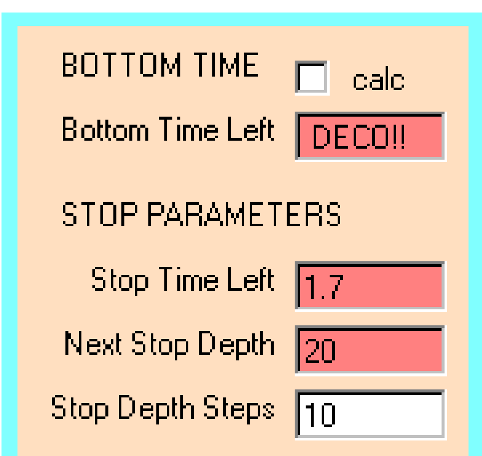
1.00; and no color indicates a risk between 0.00 and 0.50. These displays are a summary result derived from the information presented in the matrix at the bottom of the ***CDP*** GUI.

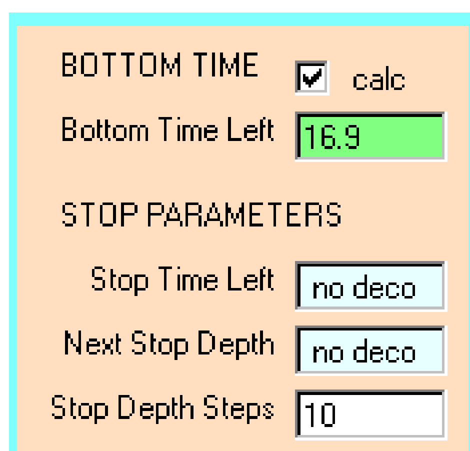
Compartment	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Total Gas Pressure	2.89	2.80	2.54	2.24	1.93	1.67	1.46	1.28	1.15	1.07	1.01	0.96	0.93	0.90	0.87	0.86
Total Gas Pressure Ratio	0.38	0.42	0.40	0.26	0.02	-0.26	-0.63	-0.99	-1.35	-1.66	-1.94	-2.23	-2.54	-2.89	-3.21	-3.52
Nitrogen Tissue Pressure	2.89	2.80	2.54	2.24	1.93	1.67	1.46	1.28	1.15	1.07	1.01	0.96	0.93	0.90	0.87	0.86
Nitorgen Pressure Ratio	0.38	0.42	0.40	0.26	0.02	-0.26	-0.63	-0.99	-1.35	-1.66	-1.94	-2.23	-2.54	-2.89	-3.21	-3.52
Helium Tissue Pressure	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Helium Pressure Ratio	-0.52	-0.69	-0.87	-1.08	-1.26	-1.47	-1.71	-1.98	-2.22	-2.44	-2.59	-2.70	-2.74	-2.80	-2.84	-2.91

This matrix shows the tissue-compartment loading for each of the inert gases and the total of both gases in the breathing mixture in each compartment. The example below shows the pressure of N_2 and He in each compartment at the 30' stop of the dive illustrated above. The pressure of He is 0.00 in all compartments because, in this example, the breathing gas is air. The pressure ratio in each compartment is the gas pressure above ambient pressure divided by the difference between the M-value for the compartment and ambient pressure. A positive ratio indicates the compartment gas pressure exceeds ambient pressure; a negative ratio indicates the pressure is less than ambient. The same values of gas pressure in different compartments may have different ratios because the M-values in different compartments are different. Equivalent information is shown graphically in the bar graphs that show Gas Content by Compartment described in the section on **Graphical Outputs**.

In the case being illustrated, where a 30' decompression stop is being executed, the adjacent orange frame shows the remaining time at that stop depth – 1.7 minutes – and reminds the diver that the next stop is at 20' with the diver's acceptance of 10' increments between stop depths. When the runtime is extended for the next waypoint so that the required stop time is achieved, the red will be replaced by green and the Stop Time Left box displays "ascend."

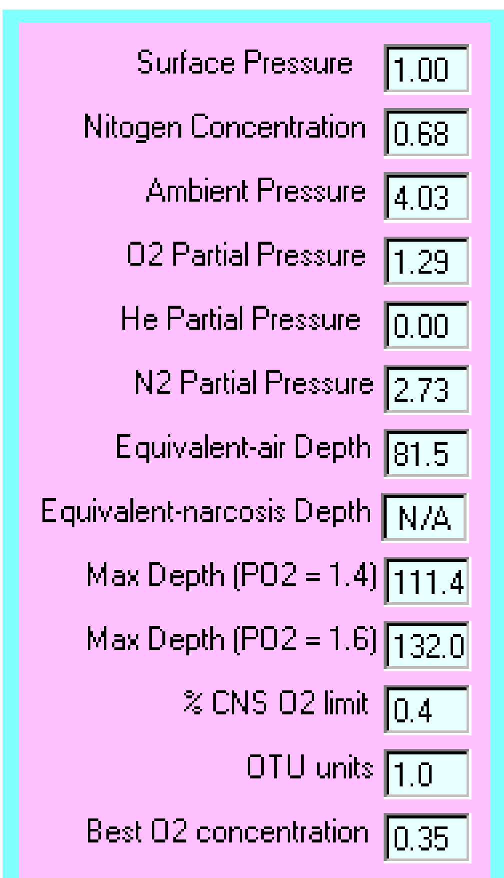
When a decompression situation does not exist, e.g., after a 1.5-minute descent to 100', the BOTTOM TIME output shows the safe time remaining for a direct ascent to the surface, e.g., 16.9 minutes. This display requires the Calc checkbox to be checked.

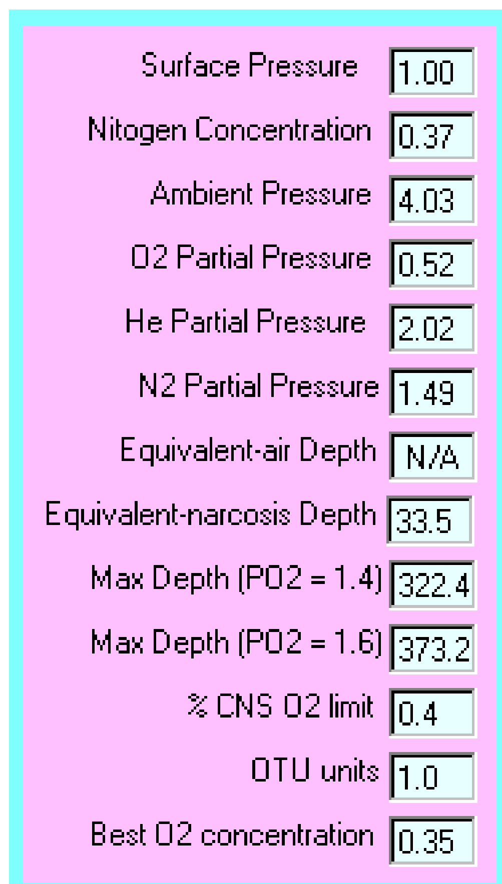




Note that the calculated remaining non-decompression bottom time assumes a direct ascent to the surface. All other calculations made by ***CDP*** are based on an ascent rate of 33'/minute (the default) or other ascent rate entered by the user. Hence, bottom times shown in this output are less than bottom times established by maintaining an absolute ceiling of 0'.

The lavender frame shows numerous additional outputs. Surface Pressure displays the pressure at the surface for the altitude entered by the diver. Nitrogen Concentration is 1.00 minus the concentration of O_2 and the other gas in the mixture, typically He. In the example shown, the gas mix is EAN/32. Ambient pressure is the pressure at the present waypoint depth; it is the sum of the surface pressure and the added pressure of the water for the entered Feet per ATA, e.g., 33 for salt water. The Partial Pressures of O_2, N_2, and He are given as a function of their concentrations and the depth, i.e., pressure, at the current waypoint. The Equivalent-air Depth expresses the depth that would impose the same decompression obligations as the waypoint depth if air were the breathing gas; naturally, this is of interest only if air is not the current breathing gas mixture. When the gas mix consists of gases other than O_2 and N_2, e.g., if He is in the mixture, then narcosis is reduced. The depth at which air might be expected to produce the same narcosis effect is given as the Equivalent-narcosis Depth; this output assumes that O_2 and N_2 are equally narcotic. The Maximum Depth for a PO_2 of 1.4 and of 1.6 ATA are computed from the O_2 concentration in the mix, and the Best O_2 concentration for the current waypoint depth also is presented. Accumulated effects of elevated PO_2 are given as the Central nervous system exposure in terms of the % of the total allowable exposure and as accumulated Oxygen Tolerance Units (OTU). Examples below show outputs for EAN/32 and for a 13/45 Trimix.





The yellow frame shows gas volumes consumed throughout the profile. If the same mix is used twice in the dive, ***CDP*** recognizes that the mix is the same and computes the total consumption for that mix. Up to 14 different mixes can be displayed.

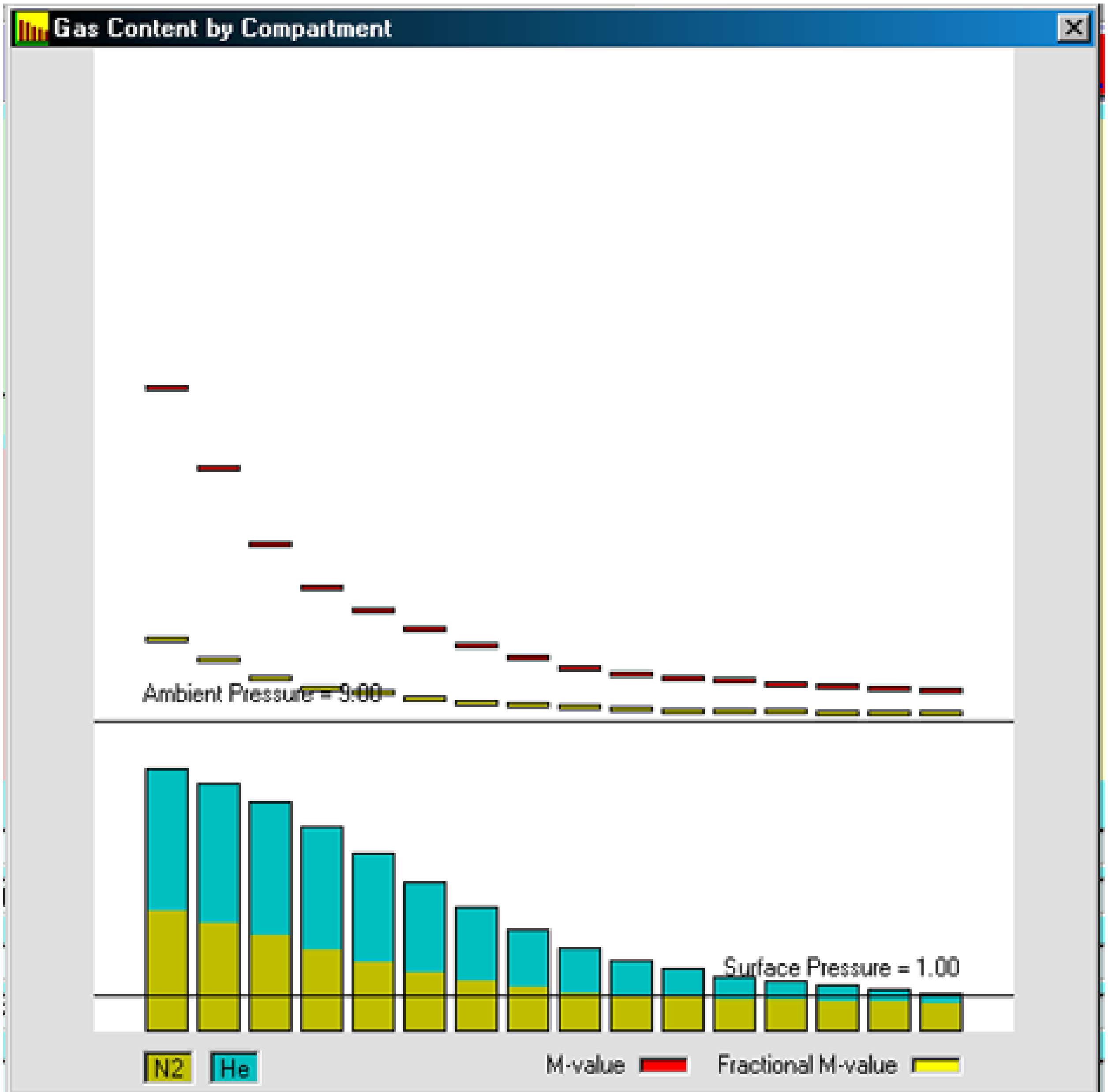
The entire dive profile is captured in a separate text file, which can be named by the user, but the default file name is "Profile.txt." A sample Profile.txt listing is shown below for a deep, multi-gas decompression dive; it is reduced in order to fit the example on a page having a "portrait" orientation, but ordinarily the user would print it in a "landscape" orientation for clarity.

DIVE/STEP	RUN TIME	DEPTH	ABS CEIL	FRAC CEIL	ABS RISK	FRAC RISK	MIX NUMB	MIX USED	CONC O2	CONC HE
1/0	0.0	0	0	0	0.00	0.00	0	0.0	0.21	0.00
1/1	2.0	132	0	0	0.00	0.00	1	3.9	0.21	0.00
1/2	4.0	264	13	38	0.00	0.00	2	7.0	0.15	0.45
1/3	24.0	264	84	127	0.00	0.00	2	97.3	0.15	0.45
1/4	28.1	130	84	127	0.41	0.55	2	111.3	0.15	0.45
1/5	29.3	130	80	118	0.33	0.77	2	114.3	0.15	0.45
1/6	29.6	120	83	118	0.42	0.55	2	115.0	0.15	0.45
1/7	31.8	120	73	108	0.31	0.73	2	120.1	0.15	0.45
1/8	32.1	110	73	109	0.48	0.96	2	120.8	0.15	0.45
1/9	34.6	110	68	99	0.31	0.65	2	126.2	0.15	0.45
1/10	34.9	100	68	99	0.45	0.96	2	126.8	0.15	0.45
1/11	37.0	100	65	88	0.28	0.63	3	4.2	0.36	0.00
1/12	37.5	90	64	87	0.43	0.89	3	5.2	0.36	0.00
1/13	39.0	90	56	80	0.29	0.63	3	6.3	0.36	0.00
1/14	39.5	80	56	79	0.47	0.95	3	6.9	0.36	0.00
1/15	42.0	80	52	68	0.25	0.51	3	13.2	0.36	0.00
1/16	42.5	70	51	68	0.45	0.89	3	14.0	0.36	0.00
1/17	45.5	70	45	60	0.25	0.49	3	18.7	0.36	0.00
1/18	46.0	60	45	60	0.51	0.98	3	19.4	0.36	0.00
1/19	51.0	60	36	49	0.21	0.43	3	26.5	0.36	0.00
1/20	51.5	50	36	49	0.50	0.94	3	27.1	0.36	0.00
1/21	59.0	50	28	39	0.11	0.21	4	9.4	0.50	0.00
1/22	59.5	40	28	39	0.49	0.89	4	10.3	0.50	0.00
1/23	68.0	40	21	30	0.11	0.23	4	19.4	0.50	0.00
1/24	68.5	30	21	30	0.54	0.97	4	19.9	0.50	0.00
1/25	78.0	30	14	21	0.14	0.26	5	5.1	0.80	0.00
1/26	81.0	30	12	19	0.03	0.06	5	11.9	0.80	0.00
1/27	82.0	20	12	19	0.51	0.89	5	12.8	0.80	0.00
1/28	148.0	20	0	0	0.00	0.00	5	65.8	0.80	0.00
1/29	152.0	0	0	0	0.59	0.98	5	68.4	0.80	0.00

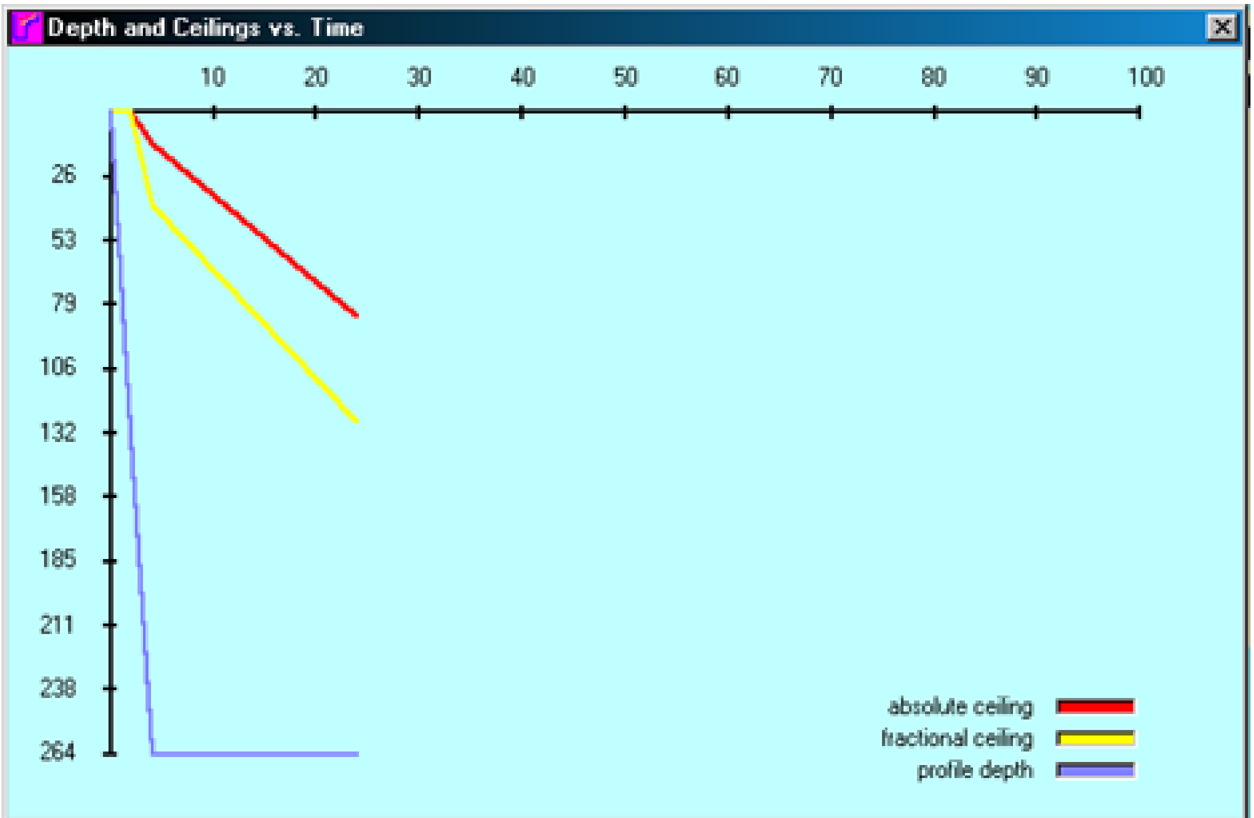
GRAPHICAL OUTPUTS

CDP provides two key graphical outputs: a bar graph displaying the gas content in each compartment and a linear plot displaying the depth vs. time profile of the dive. Both displays show absolute and fractional parameters; the bar graph shows these parameters as the M-value and gradient factor value, while the linear plot shows the absolute and fractional ceilings.

The sample bar graph shown below presents N_2 and He pressures at the end of the working portion of a trimix dive. N_2 values are shown below He values; the bar height indicates the total gas pressure. Note that the pressures in the lower compartment numbers, which correspond to the faster tissues, are higher, but M-values also are higher for the faster-tissue compartments.



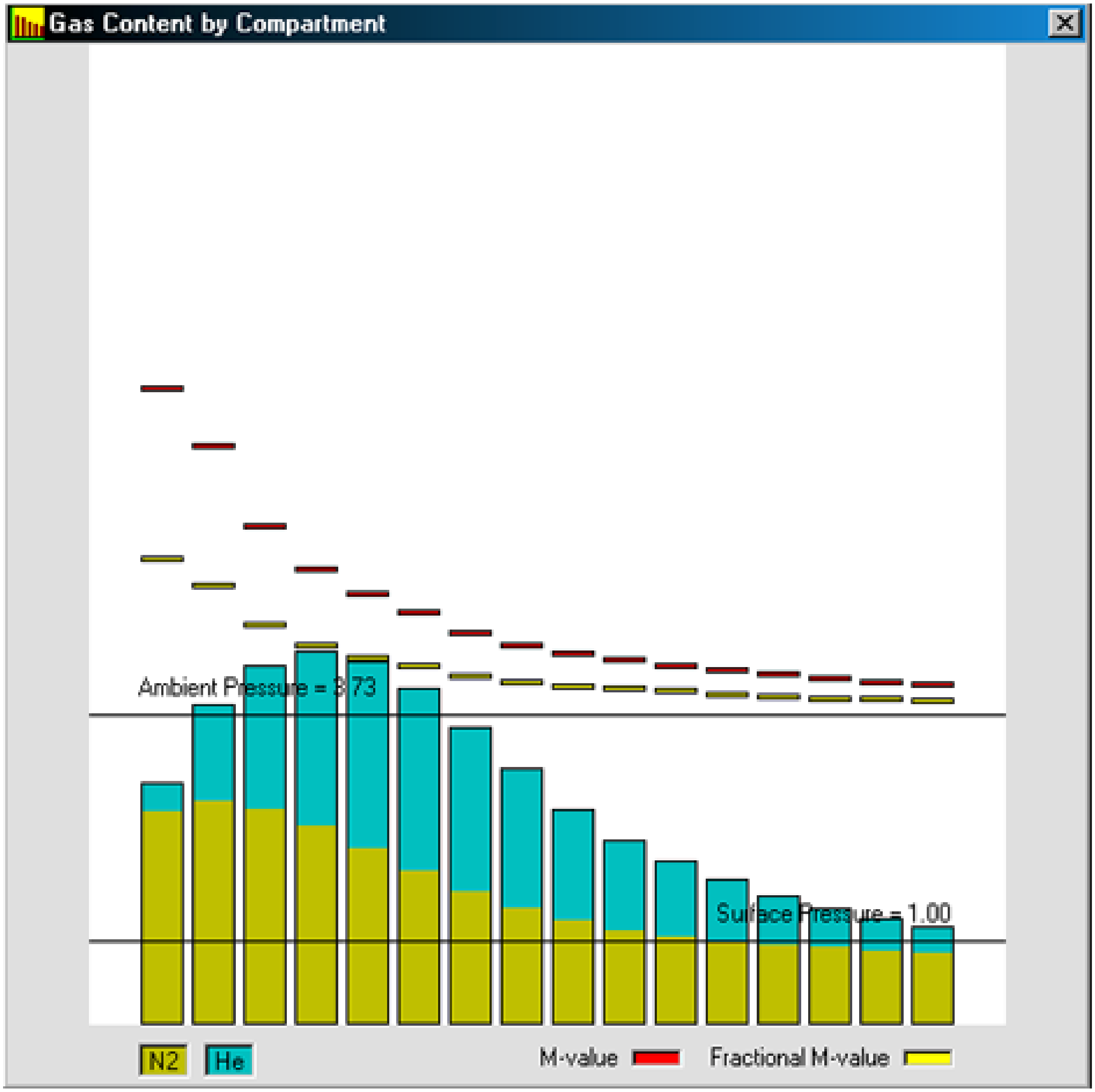
The corresponding depth vs. time plot shows the dive profile along with clearly increasingly deep ceilings. Note that this plot uses straight lines joining pairs of waypoints. However, the user can portray the developing ceilings that develop as curves over time by using numerous, closely-spaced waypoints rather than simply entering waypoints at the start and end of a stage, such as a constant-depth portion of the profile.



Note that both types of output automatically rescale, but the user can specify scaling to optimize viewing for the user's purposes.

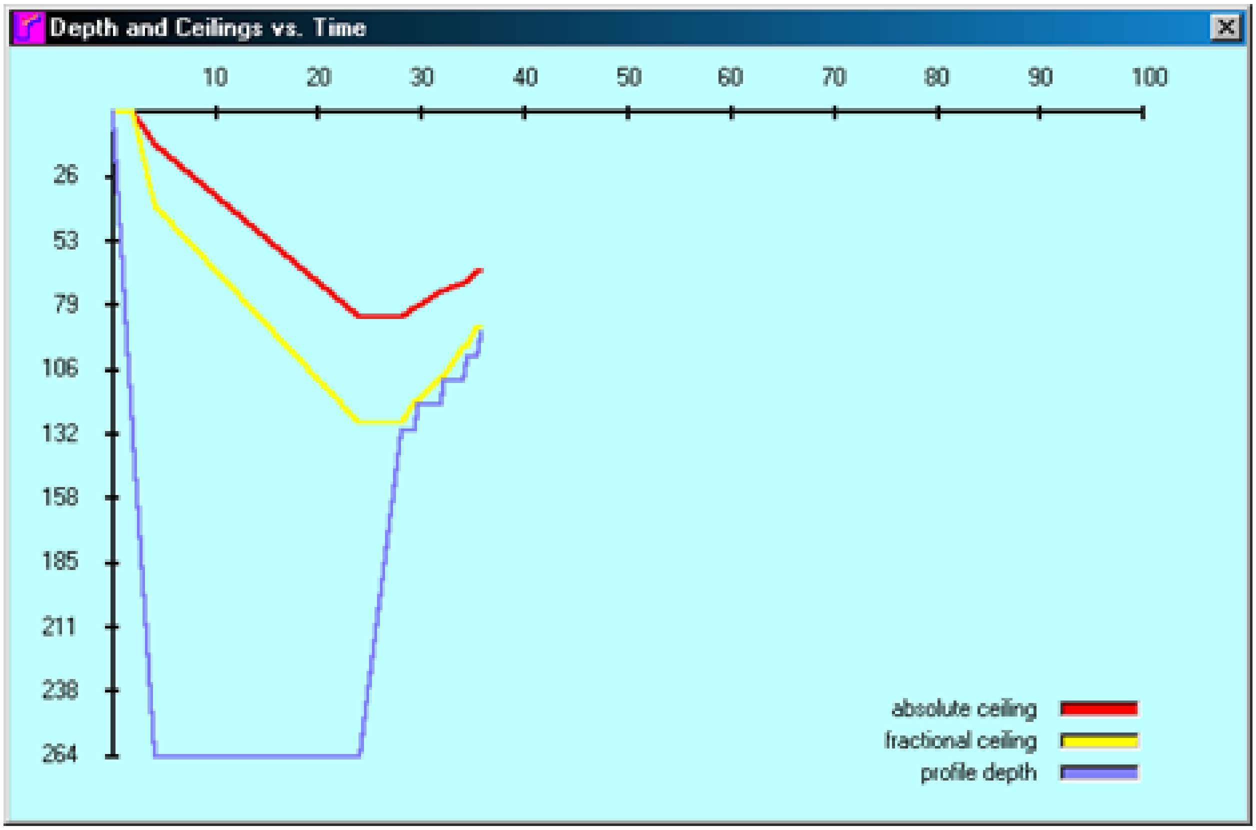
These graphical outputs are particularly interesting on ascent as ambient pressure, M-value, and gradient-factor value decrease while gas pressures in faster compartments decrease when they exceed ambient pressure, but gas pressures in slower compartments may tend to increase. These pressure increases in higher compartments can lead to a need for extended top times at shallow stops if deep stops are longer than the minimum required time. Therefore, as these tools can so clearly show, decompressing divers should ascend directly to the first decompression stop, and stay at each stop for the prescribed time before ascending to the next stop, which generally should be 10' shallower. (The exception might be maintaining the 20' stop for an extended period rather than risking dangerous depth fluctuations at 10' stop under conditions of heavy sea conditions and surge.) These tools also show dramatic benefits in terms of reduced decompression time that result from maximizing the gas gradients, e.g., by utilizing EAN during ascent to flush He and then N_2.

The graphical outputs below show a diver's status during the ascent from the trimix dive illustrated above while using EAN/32 starting at a depth of 110'.



Note that in planning this dive, the minimal time spent at each stop puts the total gas pressure in the most-burdened compartments immediately adjacent to the fractional M-value. The values of all fractional M-values in turn are determined by the surface and deep gradient factors and by the conservatism specified by the diver.

This effect also is clearly shown in the profile graph where the depth profile follows a step pattern in which the depth plot closely approaches but does not touch or cross the fractional ceiling, which is determined by the fractional M-value and hence by the user-specified gradient factors and conservatism. As stated previously, the ceiling profiles actually follow curved paths between waypoints, and if the curvature is of interest to the user, then closely-spaced waypoints can be entered.

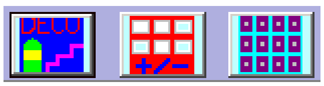


At this point, ***CAI*** needs to reiterate the warning that this User's Manual cannot substitute for proper training in the principles underlying the tools offered by ***CDP***. The Manual certainly does not provide any basis for developing the diving skills needed to execute the plans formulated using ***CDP***. ***CDP*** and this Manual should not be used for planning and executing dives without proper training and certification by an appropriately qualified instructor. Proper training in concepts and dive skills and adequate fitness are essential for safe use of ***CDP*** in diving at any level from recreational through extreme technical.

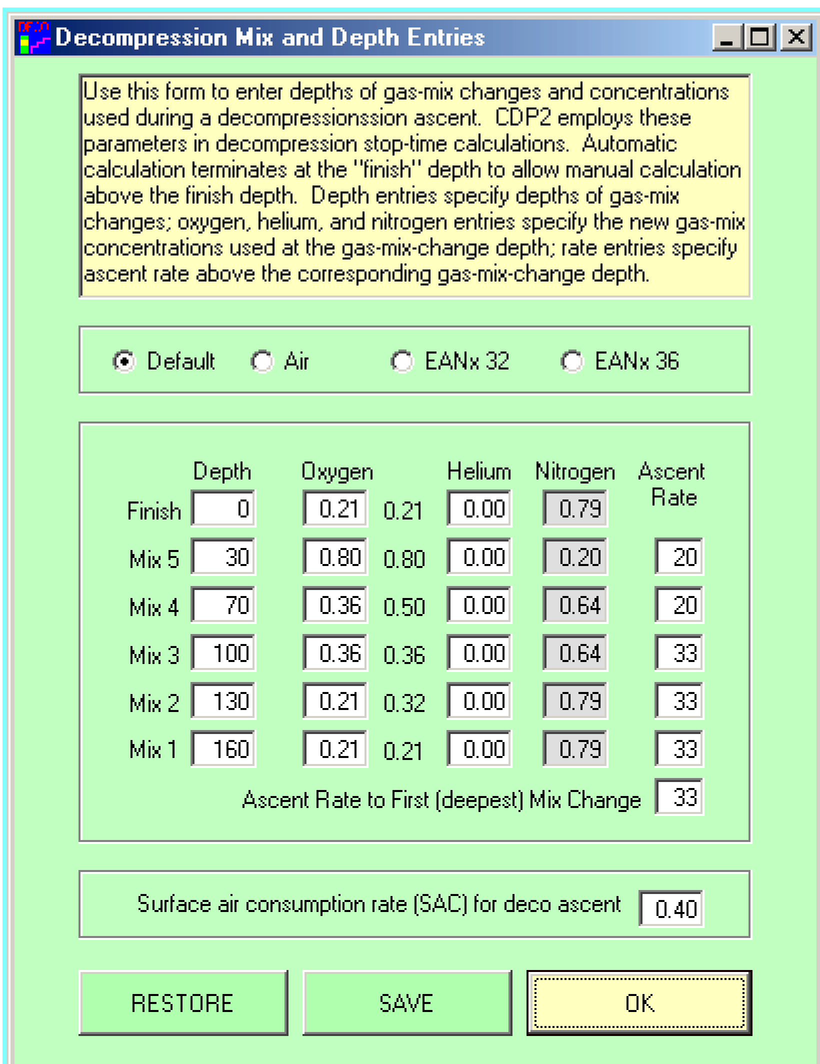
DESCRIPTION OF CDP-2

CDP-2 is an enhanced version of ***CDP*** that includes provisions for automatic calculations of decompression stop times and determination of the deepest (i.e., first) stop depth. ***CDP-2*** has several features that are not required for the basic ***CDP***. For example, ***CDP-2*** provides means of setting and customizing ascent parameter values. The output text file generated by ***CDP-2*** is simpler than the file generated by ***CDP*** and emphasizes parameters of interest in planning technical dives – including dives that require stage decompression. ***CDP-2*** also uses a more-sophisticated means of estimating CNS exposure. ***CDP-2*** is described below in terms of features that distinguish ***CDP-2*** from the basic ***CDP***.

INPUTS

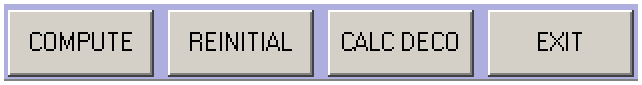


A key new feature of ***CDP-2*** is the decompression command button that appears at the upper right of the main window when ***CDP-2*** is initialized. Clicking on this button displays a new window for entry of decompression-related parameter values.



Initially, the decompression mix and depth entry window presents the default values of decompression-gas composition, gas-switch depths, ascent rates, and gas-consumption rate (referred to the surface). The user can change any of these values. *Note that the "Finish" depth can be different from 0 feet.* This important feature allows the user to terminate automatic calculations at a greater depth, and to calculate remaining stops manually, e.g., if a 10-foot stop is not desired. Option buttons also allow all gas mixes to be set to a single mix, e.g., air, EANx 32, etc. The window includes command buttons for saving user-selected values in files that can be named by the user and for restoring user-selected values by opening the appropriate file.

When a decompression situation arises, i.e., when no-decompression limits are exceeded, then a CALC DECO command button automatically appears at the upper left of the main window. When this command button is clicked, automatic calculation of the decompression profile proceeds based on the parameters used in the decompression-entry window.



OUTPUTS

The gas-content bar graph and the profile-plot graph evolve as the decompression calculations proceed, and they can be observed alongside the main window.

The ***CDP-2*** output text file, which normally has a default name of "Profile.txt," has fewer entries than the basic ***CDP*** output file, but adds a stop-time entry to the run-time entries of the ***CD***P file. The illustration below shows Profile.txt for a dive to 165 feet using air and default decompression parameters as viewed in the simple Notepad word processor.

Profile.txt - Notepad

File Edit Search Help

01-Apr-2001 10:15 PM

DIVE/STEP	DEPTH	RUN TIME	STOP TIME	MIX NUMB	MIX USED	CONC O2	CONC HE	PPRES O2	CNS %	OTU
1/1	165	3.0		1	5.3	0.21	0.00	1.26	1.6	1.7
1/2	165	53.0		1	155.3	0.21	0.00	1.26	27.6	72.5
1/3	160	53.2		1	155.7	0.21	0.00	1.23	27.6	72.7
1/4	130	54.1		1	158.2	0.21	0.00	1.04	28.0	73.8
1/5	100	55.0		1	160.2	0.21	0.00	0.85	28.2	74.6
1/6	80	55.6		2	1.1	0.36	0.00	1.23	28.5	75.5
1/7	80	56.0	0.4	2	1.7	0.36	0.00	1.23	28.7	76.1
1/8	70	56.3		2	2.2	0.36	0.00	1.12	28.8	76.5
1/9	70	60.2	4.0	2	7.1	0.36	0.00	1.12	30.5	81.3
1/10	60	60.7		2	7.9	0.36	0.00	1.02	30.7	81.8
1/11	60	65.2	4.5	2	12.9	0.36	0.00	1.01	32.3	86.4
1/12	50	65.7		2	13.6	0.36	0.00	0.91	32.4	86.9
1/13	50	73.4	7.7	2	21.3	0.36	0.00	0.91	34.7	93.3
1/14	40	73.9		2	21.9	0.36	0.00	0.80	34.8	93.7
1/15	40	85.5	11.5	2	32.2	0.36	0.00	0.80	37.3	101.2
1/16	30	86.0		2	32.7	0.36	0.00	0.69	37.4	101.5
1/17	30	98.5	12.5	3	9.6	0.80	0.00	1.53	50.4	124.2
1/18	20	99.0		3	10.0	0.80	0.00	1.29	50.7	125.0
1/19	20	116.0	17.0	3	21.4	0.80	0.00	1.28	60.7	150.9
1/20	10	117.3		3	21.8	0.80	0.00	1.04	60.9	151.5
1/21	10	150.3	33.0	3	39.0	0.80	0.00	1.04	73.4	186.8
1/22	0	150.8		3	39.3	0.80	0.00	0.80	73.5	187.3

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