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Product description:

# DECOMPRESSION COMPUTATION AND ANALYSIS PROGRAM

# DCAP version 6.7

## What is DCAP?

"**DCAP**" is a comprehensive computer program that serves as a **tool** for the generation and analysis of **decompression tables and profiles**. These "tables" are for decompressing people who may be exposed to elevated air or gas pressure followed by a reduction of pressure. This applies mainly to divers and caisson and tunnel workers, but decompression procedures can also be needed by hyperbaric medical personnel, researchers and subjects, and occasionally by submariners. An important application is for patients in hyperbaric therapy, especially those with complicated decompression sickness or gas embolism, and for the attendants who care for them. Decompression techniques are also needed by astronauts and high-altitude aviators. While DCAP has many uses, its terminology and this description are—for convenience—oriented toward diving. A decompression "table" or "schedule" is a specific plan for pressure reduction or ascent, using designated breathing gases, so as to return to normal pressure (or go to reduced pressure) with an acceptably low risk of decompression sickness or related problems.

DCAP is designed to be used by engineers, diving operations managers, doctors, hyperbaric technicians, physiologists, and various kinds of researchers—anyone who needs decompression information and who knows the necessary operational techniques and understands the physiological limits involved. Basic "PC" computer skills are required, but it is not necessary to be a programmer to use DCAP.

This memo first covers the main principles of DCAP, then describes some of the configurations and options available.

## How DCAP functions

To generate decompression tables with DCAP the User (the DCAP operator) enters a one-page set of instructions into a personal computer (PC); this set of instructions describes the dives to be done, the gases to be used, the profiles to be followed, the instructions to the diver, etc., and is called a **Basecase**. The Basecase also references other previously prepared computer files that define or specify many other variables to be used, such as the system of units, the computational model and its characteristics, ascent limits (e.g., "M-values"), the table printout configuration, oxygen limits, and the output files to be generated. The **Basecase** instructions are in normal language (usually but not necessarily English) and are written in diving and not computer terminology. A sample of a Basecase for an oxygen-helium-nitrogen "trimix" dive is shown in Figure 1.

**DCAP uses various computational models**

The development process for decompression procedures requires the application of practical experience with previous decompressions, both good and bad, to the production of future tables. This transition step is usually done by means of a computational "model" or "algorithm." A number of models have been used by decompression developers, and they are still evolving; some are better than others, but all are subject to improvement, and all those that work well rely heavily on **experience.**

DCAP is a practical result of many years of collective experience in preparing and evaluating many types of decompression tables. The DCAP concept does not limit it to calculations with any specific model—there is currently a choice of several models, and others are under development. DCAP's main feature is that it **facilitates the computational and table production process**, but it can allow different approaches, models, ascent constraints, and table configurations to be used.

```
C New NOAA trimix tables for greater depths
c
 base.case  dm93t0.h00
C           <-----------------------t-------------------a----------------66>
 purpose    NOAA Trimix 14/60 tables (Extended). 200-300 fsw.  14(13-15)% O2,
            60 He, bal N2. mf11f6nf. 36% O2 Enriched air at 110, inwater; O2
            from 20 fsw. Forced 1 min stop at 110. RMV 1 at depth, 0.5 in deco.

 init       FILE=IF1100.DCP
 set        TITLE=NOAA Trimix 14/60 tables
            author=rwh/dd/gg
            bottom.depth=200 210 220 230 240 250 260 270 275 280 300
            bottom.time=5 10 15 20 25 30
            bottom.mix=6
            o2.mix=3   ; uses 90% for calculations
            on.oxygen=120   ; long, to get no switch
            hypoxia.limit=.12
            summary.file=on
            graphics=off
            new.page=off

 matrix     file=mf11f6.dcp
 heading    file=hubm0m.noa
 notebook   file=noaext.dcp
c             <--8--->
 mix        1=bellmix
            2=Air o2=21 % n2=100 balance%
            3=Oxygen O2=90\100 % N2=100 balance%
            4=18TX50 O2=17\19 % He=50 % N2=100 balance%
            5=36%OEA O2=35\37 % N2=100 balance% ; comment=12
            6=14TX60 O2=13\15 % He=60 % N2=100 balance%
            7=14TX50 O2=13\15 % He=50 % N2=100 balance%
c             <------------------40------------------>
 comment    file=cfton0.noa
            21=Remain at surface for >=2 hr
            22=Begin second dive
            23=Ascend to 1st or 110 fsw at 60 fsw/min
            24=Breathe trimix 14%O2, 60%He from surface

 if.once    first.stop then rate=30
            current.depth<110 and decompressing then at.rest=on and rate=30
        current.depth=110 and stop.finished and current.stop>0 then comment=14
        current.depth=20 and decompressing then o2.breathing=on and comment=18
            current.depth=0 and decompressing then o2.breathing=off and mix=2

 profile
 set        rmv=1
 position   depth=0 rate=0 stop=0 travel=0 mix=2 comment=2
            mix=7 comment=24
 bottom     rate=0 travel=0 comment=23 2.com=6 3.com=9
 set        rmv=0.5
 decompress depth=110 rate=60
 position   depth=110 stop=1 mix=5 comment=12
 decompress depth=0 mix=5 rate=30
 position   depth=0 comment=20
 end
```

Figure 1. Sample Basecase for family of trimix dives 200 to 300 msw for times 5 to 30 min.

Our experience is greatest with the "neo-Haldanian" or "Haldane-Workman-Schreiner" model designated **Tonawanda IIa**. It can use up to 20 gas-loading compartments, allows control of half times and M-values, and can work with multiple gases and gas mixtures, in virtually any units. Other models handled by DCAP include the Kidd-Stubbs model used by DCIEM in Canada, the Tiny Bubble or VPM model developed in Hawaii, and the U.S. Navy's Exponential-Linear model using VVAL18. Saturation decompression can use the "Vann k" function that links ascent rate with oxygen level. Peterson's "t delta P" model which adjusts a decompression to account for time spent under supersaturation in decompression is available at extra cost.

### Conventional programming not necessary

The Basecase is a set of instructions, normally less than a page in length, which follows a specific but highly versatile format. It tells the DCAP program the details of the decompression table or tables to be generated. The user needs to know about the **operational** and **physiological** aspects of the decompression to be done and how to operate the computer, but does not need to do traditional **programming**. Basecases are prepared or modified as input files for DCAP using a standard word processor or text editor.

```
NOAA Trimix 14/60 tables                            DEPTH        250 FSW
rwh/dd/gg           03Sep03                         BOTTOM TIME   20 Min
dm93t0.h00          mf11f6.dcp                      BOTTOM MIX     14TX60
                                                    BOTTOM PO2   1.29 ATM
Depth Stop Dec  Run        HiPO2                    Times in minutes
 FSW  time time time  Mix   ATM                     Comments
-------------------------------------------------------------------------
  00   00   00   00  Air    0.21 Descent optional; included in bottom t.
       00   00   00  14TX50 0.15 Breathe trimix 14%O2, 60%He from surface
 250   20   00   20  14TX60 1.29 Ascend to 1st or 110 fsw at 60 fsw/min
                                 Fixed stop at 110, change gas and rate
                                 Ascent rate 30 f/m after 1st stop or 110.
 110   01   03   23  36%OEA 1.60 Stop 1 m at 110 fsw; switch to 36% EANx
 100   01   05   25  36%OEA 1.49
  90   02   07   27  36%OEA 1.38
  80   01   08   28  36%OEA 1.27
  70   02   11   31  36%OEA 1.15
  60   01   12   32  36%OEA 1.04
  50   06   18   38  36%OEA 0.93
  40   05   24   44  36%OEA 0.82
  30   15   39   59  36%OEA 0.71
  20   13   52   72  Oxygen 1.61 Breathe 100% O2 at 20 fsw, to surface
  10   23   76   96  Oxygen 1.30
  00   00   76   96  Air    0.21 Reach surface
                               Total time = 01:36 hr:mn OTU   123 units
                               Decom time = 01:16 hr:mn VC Drop = -0.7%
                               Max O2 Fract= 0.38 Mix used(EA;Tx):  46 179
```

Figure 2. Sample table produced by Basecase in Figure 1. This table has a forced stop at 110 fsw. Values at bottom of table are Oxygen Tolerance Units and vital capacity drop due to oxygen exposure, and the fraction of the oxygen limit reached plus the consumption of the indicated gas mixes.

DCAP takes advantage of some techniques typical of programming. For example, a “conditional” statement (e.g., IF or IF.ONCE) can cause certain events to happen when and only when specific conditions are met. A common application is to change the gas mixture when a certain depth is reached, adding a comment to inform the crew of the mix change. This adds flexibility to DCAP table design.

In addition to its main computing program and the Basecase, DCAP uses a number of computer **files** of previously stored information for initial and default values. Essentially no quantitative data except a few default values are contained within the main program; all values are entered using files to which the User has access. DCAP generates the new table or set of tables in a file, and also can produce files showing a **summary** of tables generated, a listing of **gas loadings**, a **Notebook** file for keeping a record of what has been done, and a **Graphics** file. A sample table is shown in Figure 2.

## DCAP features

### User can control almost everything

The DCAP User can **control** many operational and computational aspects of the tables being generated, including the system of units, choice or definition of the “model,” parameters of the model, descent and ascent patterns, stop patterns, breathing gases, initial conditions including repetitive status, timing method, table display method, staging intervals, instructions to the diver or operator, etc., and a variety of additional output information. A single table or a “family” of related tables can be produced with a single Basecase for one or more **depths**, **bottom times**, **gas mixes**, or

**descent rates**; DCAP will generate tables using all combinations of these. Tables can be displayed as a single complex dive to a page, or schedules for numerous bottom times for the same depth can be printed on a single table. Timing shown on tables can be as total elapsed ("running") time or time since decompression began, and can be in minutes, hours and minutes, or time of day; combinations of these can be used also.

**Saturation** decompression profiles can be prepared, using linear ascent or stages; several methods of computing the ascent are available. Complex multiday dives with daily excursions can be planned as a complete project. **Excursions** from saturation can be calculated; traditional descending excursions using gas loading as the criterion for repetitive dives have been successful in the *Repex* and *Chisat* projects. Ascending excursions can be calculated as well.

Diving at altitude and flying after diving can be handled, and DCAP can be used to decompress an aviator to reduced pressure.

When used with certain models DCAP's conservatism "factors" allow the **conservatism** of a table to be changed in several ways without changing the basic structure of the table. For example, compartment half times, inert gas loadings, or M-values can be modified during a calculation to make a decompression more conservative (or less so) under specified conditions. It is quite clear what has been done in order to achieve the extra conservatism.

### Oxygen control and monitoring

DCAP provides several methods of administering **oxygen breathing** to the diver, including breathing in timed on-off cycles independent of stop timing. Tables can be calculated using a **range** of oxygen values, with the low end of the range used for decompression and the high end for oxygen exposure. This enables gas mixes with a wider range of composition limits to be used, possibly with considerable cost savings.

DCAP can monitor **oxygen exposure** in several ways during a table computation, facilitating the monitoring and thus control of both CNS and whole-body oxygen toxicity. A set of limits of tolerable exposure of the **central nervous system** can be entered, and the table will show a warning when these limits are exceeded, as interpolated by DCAP. **Oxygen tolerance units** (OTU; traditionally known as CPTD or UPTD) are counted and can be displayed and/or checked against predetermined limits. An estimate of the reduction in **vital capacity** due to oxygen can be presented. DCAP can also warn if the diver is exposed to a **hypoxic** mixture during a dive calculation.

### Analysis of previous and ongoing dives

Virtually any exposure for which the time-pressure-gas profile is known can be **analyzed** by DCAP in terms of gas loadings and/or oxygen exposure. Likewise, an ongoing profile can be picked up and the decompression **continued**. This can be used, for example, to track the exposure history of a complicated and difficult **treatment** of decompression sickness and to prepare an appropriate decompression profile.

### DCAP provides for records keeping

The User generating new tables needs accurate **records** of what has been done. DCAP facilitates this in several ways. First, the file containing each new DCAP table starts with the uniquely named Basecase that generated it, so the source information is stored with the table. The Basecase, table, and other files generated by DCAP also have related **identification** codes so the table's computational parameters and default values are on record, and all output can be linked to its source. A naming method is recommended that makes it almost impossible to use the same name for two different profiles, even if several people are working independently on different computers.

Also, DCAP keeps a **Notebook** file that contains a record of the major factors used in each table generated, including constraint limits, summary decompression times, and a short **Purpose** statement or description of the Basecase. A **Results** entry can be added by the user after the computation, such as a comment on how a given Basecase calculation turned out. In short, the Notebook file includes what the user would put in a notebook. The Notebook file, if used properly along with other DCAP files (recommended), can provide an **audit trail** telling the history of a given table development project.

### Different languages possible

Should English not be the desired **language** the user can choose the words—the vocabulary—to be used with DCAP. DCAP's instructions (Basecases and files) can thus be translated into any language that uses roman characters. Or, different English terms can be used.

The **heading** and **comments** on tables produced by DCAP can be designed by the user and can be printed in any roman-character language. Some users with divers that do not speak English retain the English instructions to DCAP in the Basecase and support files, but print the tables for the divers in their own native language.

### Detailed manual

A comprehensive, indexed **manual** covering the basics of decompression physiology, computational methods, and the description and use of DCAP is furnished with the program. A library of sample Basecases with the necessary support files is furnished. Specific ones can be prepared for the User's anticipated application.

## Graphics

DCAP offers two options for providing graphic displays of profiles it calculates. One is a relatively primitive method easy to implement but limited in capability by today's standards, the other is a set of data points that allows the User to take full advantage of external graphics programs.

The DCAP graphics function is selected from the main DCAP menu. It allows a number of parameters such as the time-pressure profile, oxygen levels, the buildup of predicted oxygen toxicity toward tolerance limits, selected gas loadings, and several other variables of a DCAP dive to be displayed from within the DCAP program in graphics form on the computer screen.

DCAP graphs, which are in black and white, can be printed out as well. This can be done using the DOS graphics print-screen function for immediate printing, or a screen image can be captured to files that can be used by other graphics programs or advanced word processors such as WordPerfect or Word (we have not been able to get the screen capture function to work properly under Windows XP). DCAP can write a .DXF graphics file which can be read by AutoCAD or other CAD programs, whereby it can be converted to other formats such as JPEG. A sample of a graph produced by DCAP as a .DXF file and transferred into WordPerfect is shown in Figure 3.

Much more powerful is the set of data points covering every part of the dive that can be produced by DCAP as a comma-delimited ASCII text file. During calculation when the graphics function is selected DCAP produces a binary file containing the value of most all of DCAP's variables every minute during the dive. Parameters can be selected and printed into a file that can be edited and used by almost any graphics program. This file can be used as the profile to be stored in a data base, or can serve as the data part of a variety of analyses or plotting options. Most kinds of graph can be produced from this data set. Figure 4 shows a graph demonstrating counterdiffusion, prepared using the graphics program Axum.

One option for using this information source efficiently is to have "templates" to plot appropriate graphs from the results of various dive calculations.

## Experience with DCAP: Applications

DCAP has been used to generate major sets of tables which have been laboratory tested and issued for field use. Equally relevant to most facilities, however, is the use of DCAP to solve small problems involving a single dive or project.

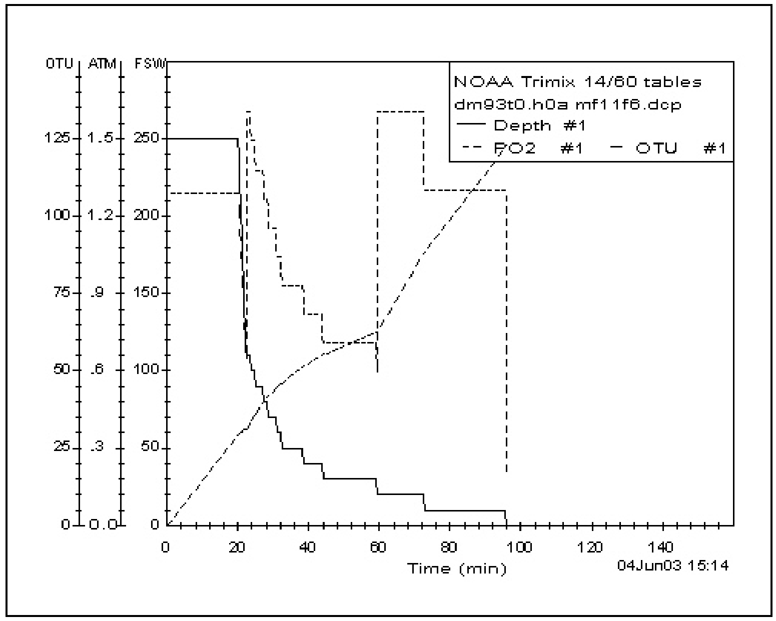


Figure 3. Sample graph of trimix dive shown in Figure 2. Solid line is depth, dashed line is oxygen level, and dot-dash line is accumulation of oxygen tolerance units.

DCAP has been used for air, trimix, and deep heliox bounce dives; excursions from both nitrox and heliox saturation, including repetitive excursions, excursions requiring stops, and ascending excursions; saturation and saturation abort tables; submarine free ascent profiles; tables for constant-oxygen closed-circuit rebreathers; deep air and enriched air ("nitrox") dives; deep dives with neon; modelling of counterdiffusion and inert gas switching; multi-level cave dives, some with exceptionally deep or long exposures; tables for deep tunnel work; transfer procedures for a hyperbaric air lock proposed for a space station, and many others. Sample Basecase forms are available to DCAP users for these dive types; model parameters and ascent constraints for many of these actual dives are available.

An important application is the ability to analyze the exposure of a patient being treated for decompression sickness, embolism, or counterdiffusion sickness (i.e., various gas lesion diseases) when the treatment has followed the path of a roller coaster or yo-yo and there is now no established method on how to proceed. This could be life saving, not only to the patient but to attendants as well. Short of this, being able to ascend according to a conservative, custom, table rather than having to resort to saturation as the only "acceptable" method can effect enormous cost savings, not to mention the reduced risk. Efficient and reliable management of attendants' decompression is a most useful DCAP capability, even for "normal" treatments. (An ancillary program "Hypermode" uses a version of DCAP to perform this function for hyperbaric medical facilities.)

DCAP can be useful even where prepared and "tested" tables are available or required. The computational basis of most kinds of tables can be duplicated with DCAP, so special needs not covered by tables can be managed. Extensions of time and depth, following proper precautions, can be done, and one does not have to be limited to any specific time, depth, or gas mix combinations as is the case with "fixed" tables. Another adjustment which has come up many times in the past is the

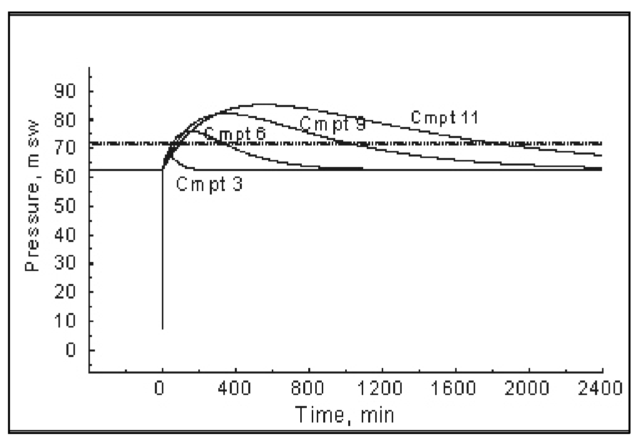


Figure 4. Demonstration of counterdiffusion. Shows 4 compartments after switch at t=0 from 90% $N_2$ to 90%He; 3 of them show supersaturation. Bitmap graph drawn with Axum 4.1 using data from DCAP graphics data file.

need to make certain parts of a table set more conservative without disturbing parts that are working well. Or, to incorporate diving supervisors' *ad hoc* adjustments based on experience into formal tables.

A significant capability is the ability to adjust tables to meet operational situations, rather than having to plan the operation to fit available tables. This has huge economic implications in its potential for savings by making more options available. For example, DCAP has been used to calculate efficient tables for a set of laboratory pressure chamber experiments that would have been impossible with conventional tables. Also meaningful is the ability to make a table use available gas mixtures that for some reason are not appropriate for the printed “book” tables; this application alone could pay for DCAP in an active diving laboratory.

Still another area where computational capability is a great asset is in working with rebreathers. Here the performance and oxygen envelope of a particular “rig” can often be efficiently matched. Excellent results have been achieved using constant oxygen partial pressures at optimal levels to perform dives for which no suitable prepared tables existed. Decompression from dives with a semi-closed rebreather is more of a challenge, but DCAP offers the ability to work interactively with the rebreather divers to optimize these decompressions. Extensive rebreather diving in one deep cave diving operation (WKPP) has been uniformly successful.

The gas loadings that may lead to symptoms as a result of counterdiffusion following gas switches can be modeled with DCAP and alternatives developed.

The very rapid ascents from a submarine during free ascent can also be modeled and the effects of various factors determined. For example, the benefit of oxygen prebreathing or a water “parachute” for the last part of the ascent can be evaluated. If experiments are to be performed this makes it possible to get the maximum benefit from them and thus reduce the exposure of human subjects to decompression risk.

Special tables for compressed air (tunnel or caisson) work at pressures well beyond the standard tables have been prepared and the various options assessed.

DCAP is in use in several naval centers, diving laboratories, and private facilities, world wide. Official tables produced with DCAP have been issued by at least two different navies.

**New options for table validation**

For many years it was considered necessary to perform laboratory chamber validation tests of all new decompression tables. A consensus of experts at the Undersea and Hyperbaric Medical Society's **Workshop on Validation of Decompression Tables** offers alternatives. In what is considered as a breakthrough in this philosophical area, the Workshop prepared a set of guidelines which have been generally recognized internationally. These allow certain interpolative adjustments to tables to be made in a manner considered ethically acceptable without chamber testing. This by no means gives the DCAP User free license to do anything desired without being answerable, but it offers guidelines on how things done with DCAP can meet accepted validation criteria, often without the need for chamber tests. For example, some new and unique tables for an archaeological project that were patterned after a series of successful deep recreational dives were put into operational evaluation without further tests; a university Dive Control Board approved this procedure. NOAA, The U.S. National Oceanic and Atmospheric Administration, has acquired a set of special trimix tables for diving on the Civil War vessel *U.S.S. Monitor* and other projects. These are identified as the NOAA-Hamilton Trimix Decompression Tables.

**Reliability estimates with maximum likelihood**

A new approach to decompression is building up around statistical methods, especially the use of **maximum likelihood**. This is a technique whereby the decompression sickness results of past dives of different types can be analyzed and used to estimate the probable occurrence of DCS ($P_{DCS}$) in a new profile. DCAP offers a limited and somewhat primitive option to provide an estimated $P_{DCS}$ on dives it calculates. These estimates are based on "calibration" on a group or "data set" of well-documented dive logs. Calibrations performed by researchers at DCIEM in Canada are included with DCAP for $P_{DCS}$ estimates for air, nitrogen, and helium based dives. They can also be run with trimix dives using both inert gases in the same dive, but with a less specific calibration. Additional calibration sets may become available. The current version of DCAP does not directly calculate "statistically based" decompression tables, but does afford a statistical estimate of the reliability of its tables.

### What DCAP is not or does not do

A potential user of DCAP should understand that the system does not immediately solve all decompression problems. A considerable store of experience comes with DCAP, but the relevance of available experience may vary considerably between different types of dive. DCAP itself cannot provide **judgement** as to choice of its many variables, but examples and advice in this area are available from HRL as part of the DCAP package.

The program requires a knowledge of **diving physiology and operations**, and some training and study of the DCAP system by the potential User in order to operate it effectively. The fact that a table was generated "by DCAP" does not specify how it was computed; DCAP can use many computational models and allows the constraints for these models to be specified in different ways.

### Versions of DCAP

DCAP has evolved through a number of revisions, and is currently available as version 6.7x. The "x" may change with small upgrades and bug fixes.

## DCAP installation

### Installation, instruction, and support package

Although the DCAP system is designed to minimize the need for programming expertise and its features are all covered in the manual, its versatility obligates a certain complexity. Our experience has been that DCAP is most effective when the User receives hands-on instruction in its philosophy, operation, and application, and some practice using it on her own computer. Accordingly, we require the DCAP Client to accept on-site instruction at the time of initial installation, and offer it again about one year later (the location can be arranged for maximum benefit). These sessions are normally for a duration of about one work week. The cost for the installation, instruction, necessary travel, and an ongoing support package is in addition to the cost for the DCAP license.

Because of the differences in location, personnel qualification, number of users, organizational needs, language, etc., each installation and training package has to be formulated for the specific site. A particular advantage of the installation and training sessions is that initial Basecases can be developed to meet immediate, specific user requirements. We recommend training a team of two or three users, but usually there is one one primary operator.

We teach the necessary computer operation for running DCAP, but we request that at least one member of the User team be familiar with the particular computer, its files and directories, and the use of a text editor before the sessions begin. All DCAP instruction and documentation are in English; if interpreters are needed they are to be provided by the Client.

Additional support on a continuing basis is available from HRL, and is strongly recommended.

The typical DCAP installation includes one year of support by e-mail, telephone, fax, and surface mail as applicable. Correction of bugs is provided without extra cost (for up to 5 years if needed), and updates dealing with convenience factors and additional features will be provided as they are developed during the support period, at no cost or nominal cost.

An agreement for additional support beyond the first year is highly recommended, and can be included with the main system.

**Computer requirements**

DCAP will runs comfortably on any modern computer capable of running Windows, and on many with far less capability. All versions of DCAP run on computers of the IBM PC line, and equivalents. A hard disk is highly desirable, and a printer is needed. DCAP is a DOS program, but it runs well under all versions of Windows. For older computers DCAP is much faster when used with a math coprocessor. DCAP is written in FORTRAN 77 (currently Microsoft version 5.1). A graphics video display is needed to run the DCAP graphics, either CGA, EGA, or VGA.

A Macintosh version of DCAP has been developed, but DCAP performs much better on a Macintosh by running it in a DOS or Windows emulator.
A text editor that produces ASCII files ("text" files) is necessary; a suitable one is furnished but any can be used, including the WordPad that comes with Windows or any word processor. The preferred editor is one the User is familiar with; the only requirement is that ASCII files can be produced, and it must be possible to control the extension of the filename.

## Options available with DCAP

In the process of developing and using DCAP, Hamilton Research has developed some additional related capabilities which are offered as extra-cost options. These are briefly mentioned here; additional information will be furnished on request.

### 1. Ongoing support

Hamilton Research offers to provide additional User support for DCAP beyond the first year on a continuing or annual basis, according to an arrangement specific to each Client. A minimum of one visit to the User's facility per year is recommended. This can include other aspects of decompression technology in addition to DCAP, such as oxygen management, planning of operations and experiments, and participation in specific research projects. Arrangements can be made to suit the Client's requirements.

HRL has invested considerable effort in the ethics and politics of decompression table development, including the process for validation of new tables. We can offer advice and guidance in setting up development protocols and establishing validity for new tables.

### 2. The t-delta-P model

It has long been observed that decompression tables, particularly those calculated with Haldanian techniques, have less reliability (i.e., more DCS) in the longer, deeper dives. To deal with this an additional constraint has been developed. This uses the integral of supersaturation over time as an additional ascent limit. The "tΔP" parameter is calculated for the exposure, compared with an empirically determined limit, and the profile is recalculated (if necessary) at a slower rate until the tΔP value is cleared. By arrangement with the developer of this technique, Dr. R.E. Peterson, we are able to offer it as a DCAP option at extra cost.

### 3. Treatment manual and Basecases

Despite all good intentions and best efforts, occasionally a diver gets decompression illness. Consensus methods for **treatment** of these disorders are becoming available for surface-oriented cases (divers at the surface, such as recreational divers), but for some less common situations such as DCS following dives in a deep diving system or saturation-excursion dives, there are no accepted standard procedures. We have developed to go with DCAP a comprehensive field-oriented manual on the pressure and oxygen aspects of treatment of DCS and embolism. This is particularly relevant to deep chamber or bell oriented diving operations. The treatment package incorporates the essence of current thinking about treatment. More meaningful, however, are sample

Basecases to make it possible to run these treatments in a "custom" way using DCAP to match the treatment to the exposure.

**4. Source code and flow chart**

Some users are able to use DCAP's FORTRAN program code to improve the program's effectiveness, for installing it on an alien computer, for example, or by being able to make small changes or corrections on telephone or fax advice.

Although the DCAP Client will have a permanent license to the DCAP program and the full right to use it, we have to charge extra to provide the annotated FORTRAN source code. This includes the program set on disks and a modular flow chart showing how the DCAP program operates at the source code level.

## Administrative details

**License**

DCAP was designed by D.J. Kenyon and R.W. Hamilton, and principal programming is by Mr. Kenyon. The program is copyrighted by and can be licensed from Hamilton Research, Ltd. A DCAP package can be designed to meet the users needs and in consideration of the budget. A typical package includes installation on the laboratory's computer, a week of instruction in the use of DCAP, a supply of files and Basecases for appropriate dive types, and support for one year. A second instruction session is offered and recommended.

The DCAP software may be backed up and used on more than one computer under the control of the using organization, but it is not to be distributed outside that organization except by written arrangement with HRL.

The price of the full DCAP system with support is lower in price than has been charged in many cases for a **single set** of commercial decompression tables.

**Statement of risk**

Any significant pressure reduction causes a finite risk of decompression sickness or gas embolism to the persons involved, and no method of computation or practical decompression technique can reduce this risk to zero.

Neither Hamilton Research nor the authors of DCAP can be responsible for any direct or consequential damage that may result from the use of the program or its products.

**Feedback of results**

Hamilton Research requires an organization acquiring DCAP to agree to feed back results of dives performed with tables generated using DCAP, and of the performance of DCAP itself.

**Distribution of tables**

The license for DCAP authorizes the using organization to produce tables for its own use. Tables may be distributed to others with the proviso that the Client organization maintain cognisance of their use and that general results be "fed back" to HRL in the same manner as other results of DCAP use.

The DCAP software may be backed up and used on more than one computer under the control of the using organization, but it is not to be distributed outside that organization except by written arrangement with HRL.

FOR MORE INFORMATION contact Dr. R.W. Hamilton at letterhead address.