cle twitching in his lower legs.

He was transferred by helicopter to Whangarei. Here he was further assessed. He was pale and clammy, but alert and orientated, with an irregular pulse. His cardio-vascular system was otherwise stable with good cardiac output and respiratory status. Arterial blood gases showed a PO_2 of 250 mm Hg (on 6 l/min O_2), PCO_2 of 52.9 mm Hg, otherwise they were normal. An ECG and chest X-ray were normal. An intravenous drip was inserted and he was sent on to RNZN Hospital in Auckland for recompression.

In transit, despite 30 mg of papaveretum given intramuscularly he was in constant discomfort, rubbing his abdomen and some shakiness of his left leg continued. Treated with a table 6A in the naval recompression chambers, his symptoms resolved readily under pressure. He was neurologically normal the next day and was sent home symptom free. The differential diagnosis included aerophagy, mesenteric arterial gas embolism, free peritoneal gas or a combination of these.

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1 Edmonds C, Lowry CJ. and Pennefather J. *Diving and subaquatic medicine*. 2nd edition revised. Sydney: Diving Medical Centre, 1983 392

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THE DEVELOPMENT OF THE RECREATIONAL DIVE PLANNER

Ray Rogers

Summary:

Depth increments in the US Navy tables are too great. The repetitive dive table is based on the slow-responding 120 minute tissue compartment, so little surface credit was obtained. This compartment was largely irrelevant to recreational diving. The repetitive group format was unsuitable as the time/depth benefits were unharmonious and times were excessively rounded off, creating anomalies. Research suggested lowering of no-stop limits. It become apparent that wholly new tables were appropriate as the USN tables were too "coarse" were not planned for extensive repetitive diving and the USN tables do not permit multi-level diving.

The compartment structure seemed wrong as there were too few compartments and they were internally inconsistent. I added compartments and adjusted their values. The 120 minute compartment never seemed to have an effect while the 40 minute tissue usually controlled the dives. The 60 minute tissue occasionally controlled and was chosen for controlling the repetitive dive calculation. The resulting table was more conservative and the time penalties were not great. The 120 minute compartment is important in long, deep dives with staged decompression.

The basic concept of theoretical model was Haldanian, retaining exponential gas exchange and a spectrum of tissue compartments. The modifications were variable maximum allowable tissue pressures, an increased number of compartments, Hempleman's power function used for the non-stop curve, shallow and deep asymptotes added, the no-stop curve was smoothed and faired, "M-values" were derived from this curve, discontinuities were eliminated and no-stop limits were lowered.

The table was designed as a circular slide rule in polar format. Multi-level capability was included. The procedure is that the dive always goes from deep to shallow. Adjustments were made to keep pressures within limits by minimum depth differentials on ascents and time restrictions were added to no-stop limits. Safety stops at 15ft/5m were recommended after all dives. These stops are required after some dives, those deeper than 100ft/30m and when within 3 pressure groups of any limit. The advantages of stops are: a dramatic reduction of tissue pressures, compensation for staying too long, compensation for diving too deep, compensation for gauge or timer error, and a slower ascent rate. There are special rules which require long surface intervals occasionally. These are when pressure groups become very high, as after repeated long, shallow dives. The rules are seldom required, but they exist.

Introduction

It is a great pleasure to be able to speak to SPUMS about the development of the Recreational Dive Planner, so enthusiastically and overwhelmingly embraced by over 95% of the medical community Down Under. Unfortunately those people have been so struck dumb by the brilliance of it all that they have remained absolutely mute and have not been able to comment. But the five per cent who are not excessively enthusiastic have written horrible letters and and numerous articles. So I would ask that they briefly give a few moments of their attention to this talk about the development of the Recreational Dive Planner (RDP) and the corporation that was created to develop it, Diving Science and Technology (DSAT). The Recreational Dive Planner comes in a rotary format, the PADI Wheel, and also in conventional tabular format.

The need for new tables

The RDP has filled a clear and obvious need for a new table. I suggest that the need for new tables is self evident, witness the BS-AC tables and DCIEM tables. Also there are many different types of decompression computers. If the US Navy Tables were ideal, presumably these new tables would not be needed. Presumably the network of recompression chambers around the world would not exist, because there would be no need for them either.

Everyone has his own private list of why the US Navy Tables should be redone. Here is my list:

Depth increments too large

First of all, I think the depth increments are entirely too great. Depth increments are in 5 foot steps from thirty to forty feet, and thereafter ten feet, (Bear with me, Australians think in imperial units much better than I think in metric, so will be imperial all the way). What I call coarseness is a large decrease in available time with a small increase in depth. Between forty and fifty feet bottom time drops from 200 minutes to 100 minutes, entirely too big a step in my opinion.

Need for shorter no-stop limits

Research has suggested that there should be lower no-stop limits. During the 70s and 80s many people investigated the application of Doppler technology to diving, but it was Merrill Spencer[1] who first suggested that, for recreational use by the average diver, no-stop limits in the US Navy tables were a bit high.

If one simply wanted to reduce no-stop limits, it would be easy to take a waterproof marker to the old tables and mark the new limits on them. In fact, this has been recommended in an article in the Undersea Journal, PADI's house organ.[2]

Repetitive diving table problems

There are other issues such as the repetitive dive table being based on the very slow responding 120 minute half-time theoretical compartment. I will refer to it as a compartment or tissue. If a 120 minute half-time tissue is exposed to a pressure gradient, after two hours it has taken up to half the gas load that it can take up. It will take a further two hours take up half the remaining potential gas load. In other words these tissues have exponential uptake of gas. Since most recreational dives encompass a much shorter time span , what is the relevance of the 120 minute tissue?

In the PADI version of the USN tables ,for recreational divers, at the top of table two, is printed "surface interval credit table". In my opinion it should be the surface interval "no-credit" table, because sometimes after approximately 45 minutes one is in exactly the same pressure groups as one started in; one gets no credit at all. If one happens to be in groups E through H and on the surface for something like an hour or an hour and fifteen minutes, which is very common in recreational diving, there is a gain of one group, because the groups are not small enough. When the USN originally calculated the the repetitive dive table, they had a total of 31 pressure groups, differing by the equivalent to one foot of seawater absolute. But to simplify things, they grouped them together into two feet of seawater pressure groups. So we are burdened by a broad pressure range secured by a very slowly responding tissue.

If one looks at the residual nitrogen times one sees that at one depth the time gained by the diver as he is off gassing, going from pressure group to the next, on the surface is quite small. But as one goes vertically, from depth to depth for the next dive, the increments are very large. That is what I mean by coarseness. The groups are too large and the surface interval credit table is quite unresponsive. The tables were rounded off excessively, and created many internal anomalies. The residual nitrogen time table was calculated to the nearest minute, while the front part of the table was calculated and rounded off to the nearest five or ten minutes. This was originally based on the Navy Experimental Diving Unit (NEDU) reports in 1955-1957[3-6] which recommended that it should have been recalculated to the nearest minute. This was never done, and as a consequence there are a lot of anomalies.

My personal favourite, which combines all these discrepancies, is this example. If I am on a repetitive dive and my total bottom time is 141 minutes, and I have been at exactly 40 feet for this entire time, all the tables grant me virtually another hour of bottom time. But if I descend momentarily below 40 feet, say to 41, I am now under a decompression obligation. I find this quite unreasonable. I have asked a lot of people why it should be this way, and they say, "That's the Navy table". But I am not in the Navy and I do not care. I tried to find an answer, but nobody knew why. Nowadays, I think a lot of people know, but even five years ago knowledge was very sparse on the subject.

Reworking the USN tables.

Luckily I found a book written about 12 years ago[7] and there was information that led to the papers[3-6] which were used to set up the original Navy tables 35 years ago, and by working my way through them I finally figured out what the Navy did when it created these tables.

I made copies of the worksheets. All the calculations were done by hand. One should try it sometime, without a calculator or computer. It may take several minutes to figure out one tissue pressure for one exposure and one compartment, and then one has to do it all over again. It takes a long, long time and it is very tedious.

In the process of doing these many, many calculations, I found to my great surprise that the 120 minute compartment was not relevant. By then I knew that these tables were based on the 120 minute tissue. But I computed typical recreational profiles (reading from my old log books for what I had actually done) and the controlling compartment was always much faster. It was typically the 40 minute compartment and I did not understand that. Along the way I noticed that there were many discontinuities in the graphs I drew. This was because there were too few tissues in the model, so I added a few of my own, 30 minutes and a 60 minutes which the US Navy had never done. They went on a scheme of 5,10,20,40,80, 120. I programmed a 30, a 60, a 90 and 100 and found that this redundancy of tissues was really quite useless because it splits a hair too fine. But adding 30 and 60 minute tissues happened to fill big gaps between the 20, 40 and 80 minute tissues. I postulated a series of dives that were long and shallow, repeated over a number of days. Once in a while the new 60 minute compartment which I had added would be the one that would reach this limit and go over. I decided that since this could apply on some occasions, we should make this the tissue of choice for calcualtion of surface interval credit tables.

Recreational diving and the 120 minute tissue

Early in 1990 I attended the meeting of the Gulf Coast Chapter of the UHMS. Some graduate students were presenting a paper about electronic computers and comparing them to the US Navy tables. They went on and on with table after table of theoretical dives and kept talking about omitted decompression time in computers, implying that the US Navy table was still, somehow, the gold standard. What they could have said equally well, was that according to the computers, the US Navy required a whole lot of unnecessary decompression time.

In Figure 1 there is a simple series of dives of 60 feet for 30 minutes, followed by a relatively generous 75 minutes at surface, a repeat of 60 feet for 30 minutes, repeat the surface interval, and repeat the dive. Across the top is the US Navy M-value or limiting pressure, the maximum allowable pressure in the 120 minute tissue permitting direct ascent to the surface. The lower line represents the actual generation of pressures in the 120 minutes compartment. At the end the dive it is about half way up to the maximum allowable pressure, and yet the tables would require about 14 minutes of decompression.

In Figure 2 the curve at the top is the combination of

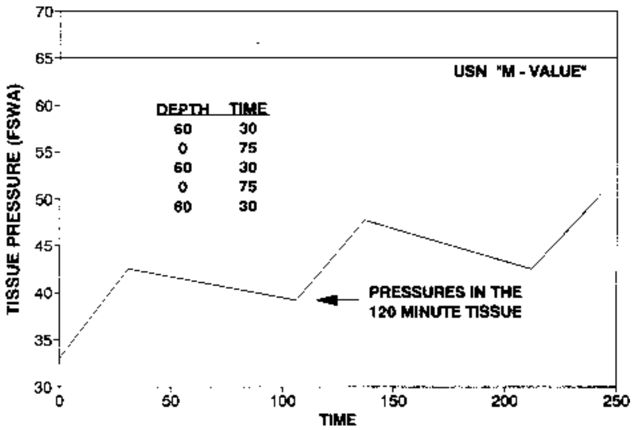

FIGURE 1

Pressures in the 120 minute compartment for a series of three dives to 18 m (60 feet) for 30 minutes with a surface interval of 75 minutes after the first and second dives.

depths and times which are required to generate the maximum pressure in the 120 minutes tissue compartment, that the US Navy defines as permitting direct ascent to the surface. The irregular lower curve is the actual plot of the US Navy no-stop limits. There is a great gap.

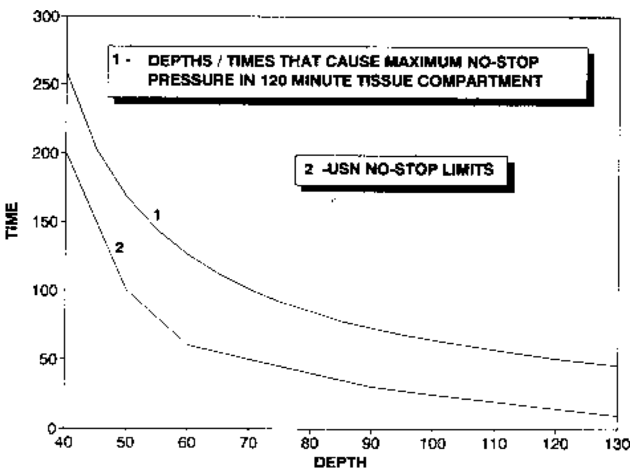

FIGURE 2

Comparison between depth/time curves, that which causes maximum no-stop pressure in the 120 minute compartmen and the USN no-stop limits.

Table 1 shows the same information for various depths. The second column, 120 max, is the number of minutes at those depths required to pump up the 120 minute

TABLE 1

TIME AND DEPTH COMPARISONS OF THE 120 MINUTE HALF-TIME TISSUE MAXIMUM AND THE USN AND DSAT NO-STOP LIMITS

Depth	120 max	USN	DSAT
40	259	200	140
60	126	60	55
80	85	40	30
100	64	25	20
120	51	15	13

tissue to its maximum allowable level and the USN no-stop limits (NDLs) are in the next column while the DSAT NDLs are in the right hand column.

One could stay for 64 minutes at 100 feet and still be the 120 minute tissue would be at a lesser pressure than the Navy says is acceptable, but the USN NDL is 25. The Recreational Dive Planner NDL is even more conservative, just a tiny little portion of the M-value. Just because something has been around for a long time does not mean that it is relevant.

Navy diving is different

Why did the USN use that compartment if it is so insignificant? Well, it was not insignificant for the US Navy, which was planning for deep, long dives such as 100 feet for two hours or 180 feet for one hour to be followed by repetitive diving. It is very significant under those conditions. But we do not do that sort of thing in the recreational world. The Navy was trying to make tables that would be able to extend working times, or bottom times, while decreasing the total amount of decompression time required, all the way to 300 feet. The idea of creating a table which might later be of use to people like us, who go out to look at pretty reefs, was the furthest thing in the world from their minds.

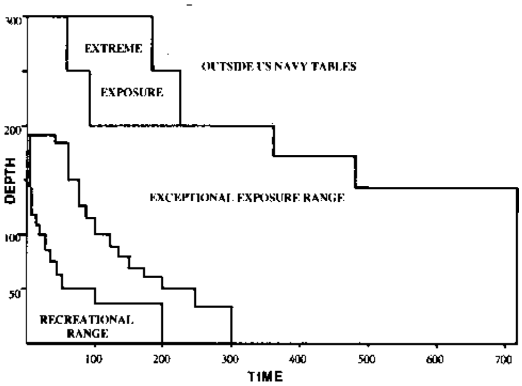

FIGURE 3

The depth time relationships of the USN tables.

Figure 3 shows graphically what I am talking about. The entire span of the Navy tables is 300 feet of depth and 720 minutes, that is 12 hours. The section down on the lower left is that part of the overall decompression tables which recreational divers, who came along some years later, borrowed from the Navy Tables, reformatted it, and called it the Navy Tables. The Navy did not mind. We only dive in the tiny bit in the corner.

We do not do salvage work or underwater demolition. What we do is look at the pretty fishes and enjoy the scenery. And for that we need something for ourselves. I am not suggesting for a minute that these tables are wrong, but just that for the diving we do they are just not appropriate.

Principles for recreational diver tables

To achieve appropriate tables we made yet another modification of the method of calculating decompression schedules, which was first developed by J. S. Haldane early in this century. Seldom has the work of a single person dominated a field for eight decades and stood the test of time so well. Virtually all tables and dive computers in existence today use some type of adaptation of Haldane's methods. It has become fashionable to deride Haldane, even as his critics continue to employ his procedures. I realize that many of his premises are considered invalid today and that there are a lot of things he did that people do not accept any more, but the man's work was brilliant. There are two things that are customarily retained from the original Haldanian algorithm, the concepts of exponential on-gassing and off-gassing and the spectrum of tissue compartments.

Through the years, there have been many adjustments to Haldane's work and current tables seem to bear little similarity to those he created in 1908. Every revision changed an earlier version to accommodate new data , and certainly, the RDP was no exception, imposing once again a great deal of modification.

This equation, $D=500\sqrt{T}$ is a variation of Val Hempleman's $Q=P\sqrt{t}$, wherein Q is a fixed quantity of dissolved gas, P is depth and t is time. In the variation, D is depth, T is time, and 500 is a derived constant which retrofits the US Navy no-stop limits to the equation. As simplistic as this may seem, the fit is generally quite good, and it is largely correct. This can be generalized to the form $D=CT^x$, which says that depth and no-stop time bear an inverse exponential relationship as described by the constants C and x (which are derived from any given table by using any two no-stop limits from the table). The equation may be rewritten in the form $D_1T_1^x = D_2T_2^x$, which suggests theoretically at least, that within the given framework of limited exposures of no-stop diving, one dive is exactly equal to another in terms of decompression stress. That may not true, but if we go with that premise we can get an advantage out of it.

Graphing the no-stop limits on a linear scale gives a sweeping curve, and if one wants to compare tables, it is difficult, because the lines are curved so much that it shows nothing. Spencer[1] showed that an exponential curve plotted exponentially or logarithmically is a straight line. This allows rapid comparison between tables. By putting one straight line on another it is easy to see which is more conservative.

The equation can work for any two observations of time and depth. One gets, in the normal recreational depth range, a remarkably good fit of my calculations with the USN NDLs. However at the extremes the accuracy falls off sharply. The formula suggests that one can do non-stop diving to 400 feet and that is not true. Even if you did not stay for any time at this depth, you would still be forced to do a decompression stop. At the other end no one is going to stay for three weeks at 10 feet. As most people ignore these extremes and stay mainly in the middle, the calculation is useful.

The anomalies bothered me. It was simple enough to correct for the error at the shallow end of the curve. One can assume that there is some shallow depth that one can go to virtually indefinitely and make a direct ascent to the surface. One can argue about what that depth is. At this depth, bottom time becomes infinite, and the no-stop limit curve becomes asymptotic with the depth. If this asymptote is added Hempleman's equation becomes ($D-A=CT^{-x}$)

A diver accumulates nitrogen all the way down and most of the way up, and there is a point at which the time spent in descending and ascending to a certain depth will equal the theoretical limit of the model, even if the diver did nothing but turn around for an immediate ascent. This calculated depth happens to be 243 feet in the DSAT model, which is obviously far beyond the permitted depth of 130 feet, but it is useful in the calculation and plotting of the no-stop curve of the DSAT algorithm. Figure 4 shows the DSAT NDL curve with the original straight line. One can see that a no-stop limit between the marks is a little more conservative than the straight line, but more obviously, the unnecessary deficiencies of the $D=CT^{-x}$ have been eliminated. At this point, we can dispense with the straight line and consider only the sigmoidal curve which reflects more realistically what no-stop limits probably are.

Development

Instead of starting with a whole series of empirical observations of time and depth and saying and draw a no-stop curve; I started the other way. This makes more sense intuitively, and if I could make empirical data match the curve at a few points, then I could start deriving a lot of data from the curve; which is exactly what I did.

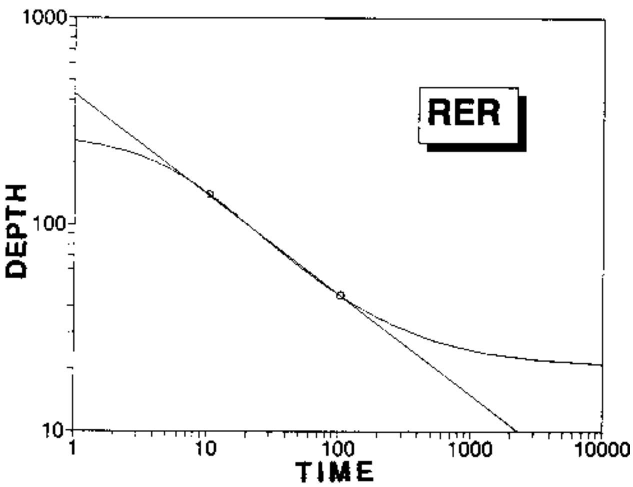

FIGURE 4

The original Rogers no-stop curve plotted, as a straight line, with the modifications needed to remove unacceptable figures (curve) superimposed.

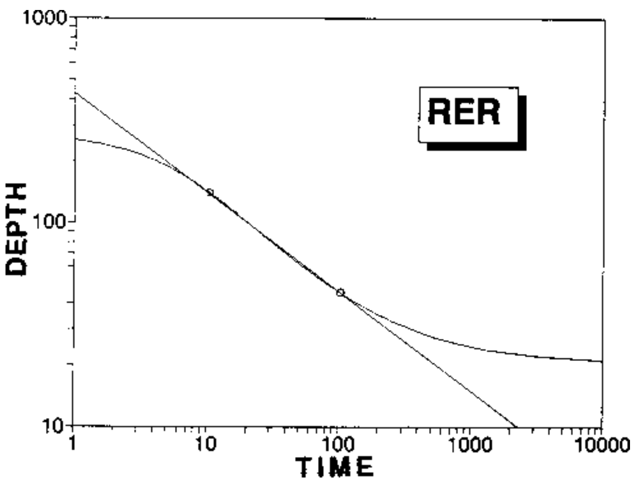

FIGURE 5

The modified Rogers curve with the RDP no-stop limits superimposed.

Figure 5 shows the no-stop limit of the RDP placed over over my no-stop curve. The little tail that sticks out at the top left is foot by foot calculations of the no-stop limits, which go all the way down the line. But one does not see them as a separate curve, because they superimpose perfectly. They superimpose because the no-stop values were derived from the empirically generated curve. I started with the no-stop limits and found a formula to predict them accurately.

Figure 6 shows the same thing done with the USN no-stop limits. They are all over the place, up and down, left and right. It is not reasonable to accept this. Intuition suggests that these irregularities and discontinuities would not exist in the water column, which is a smooth gradient

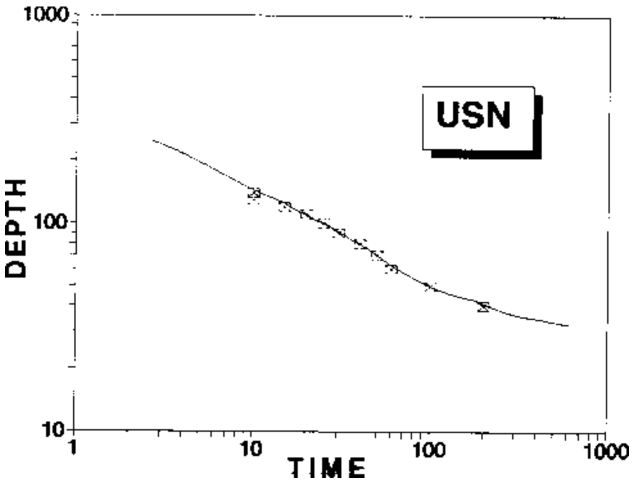

FIGURE 6

The USN curve with the USN no-stop limits superimposed.

increasing or decreasing depending on the direction one goes. I have used this concept of continuity to evaluate various other tables that are around. Take a look at them, and one finds some remarkable problems with some of the tables.

I suggest that tables should have internal consistency. I think that is important. However, every other system that I have seen, that is commercially available today anywhere worldwide, is full of internal inconsistencies.

Our tables are in based on the principle of consistency. We built them for recreational divers. Figure 7 shows that the no-stop limits which apply to the first dive of the RDP are more conservative than the USN NDLs. RDP limits

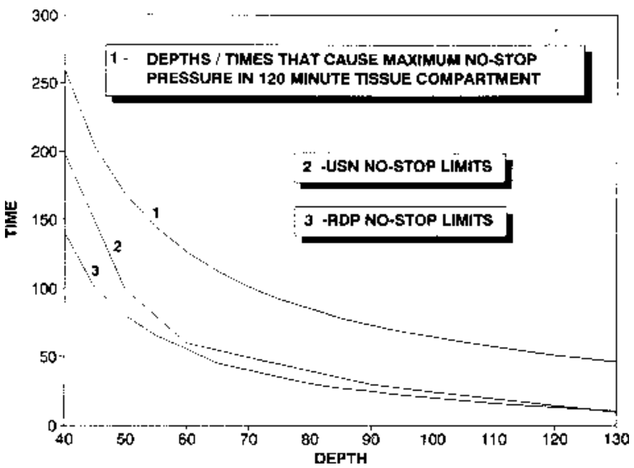

FIGURE 7

Depth/time curves showing (1) maximum no-stop pressures in the 120 minute compartment, (2) USN no-stop limits and (3) RDP no-stop limits, both for a first dive.

were taken from the curve which was developed the way as I have described.

The Wheel format

Along the way, a notion occurred to me. Instead of displaying a few episodic solutions to the whole equation for various combinations of times and depths over the place, why not use the curve itself and get rid of the rows of numbers that are found in typical tables. The RDP Wheel uses only time and depth, the only things one actually measures.

There are significant changes between the RDP table and most of the standard tables. One thing was five foot increments, which breaks up the problem of coarseness. Another, is that the RDP had multi-level diving built in from the very outset. The flat version of the RDP is basically the same as the Wheel in the information that it presents, but the Wheel presents a lot more information.

Multi-level diving

Multi-level diving is desired by a lot of divers. Multi-level diving has been part of the RDP from the outset. It is the only system that I am aware of that has been tested.

Multi-level diving is not new. These techniques have been around for 15 to 20 years One does it with existing tables by "sliding sideways" through repetitive groups to get an equivalent pressure group for a later level. But are only attempts to adjust a model that was never designed for it. Multi-level diving is quite practical, if the model is altered to allow shifting of a pressure group from greater to lesser depths. Multi-evel dives are appreciably different from "square dives". If one stops part way to the surface, it is typical that the tissue compartment which first reaches a limit is "faster" than the compartment that usually "controls" the depth, and any method that promotes such diving must provide for this occurrence and be cognizant of precisely which of many compartments is nearing its maximum tolerable pressure.

There is no table in the world today which is based on a single tissue compartment, whatever you might have heard. It is said that the US Navy tables are based on a 120 minute tissue compartment. That is only true of the surface interval credit table. It has been said that the Wheel is a single tissue model which only uses the 60 minute compartment and ignores all slower compartments. Well, people who say you that probably do not know about other things too.

No table can get away with that. The no-stop limits confirms that fact and as depths increase, the repetitive groups of the no-stop limits increase progressively. When PADI formulated its version of the old Navy Tables, it marked off its no-stop limits in black.

There are many other compartments are in the US Navy model and PADI did not want the diver going past the no-stop limits if one is doing no-stop diving.

The no-stop limits do not mean that one has gone over the limit in the 120 minute compartment. But one may have gone to the limit in the faster compartments. The no-stop limits for the greater depths are determined by the 5 minute compartment, ranging down to the 80 minute for the shallower depths. The compartments that control recreational diving range from 5 to 80 minutes when using the USN table. The 120 minute compartment plays no part, except as calculations of pressure in that compartment for use with the surface interval credit table.

Modifications required for multilevel diving

Multi-level diving is affected by many pressure groups and adjustments have to be made to stay within the limits of all the model's compartments, no matter what kind of crazy profile one may choose to adopt.

Figure 8 is a graph of two simple square dives, plotting the theoretical effect in eight theoretical compartments, and one can see the dynamic interplay of all these tissue pressures through this series of dives. If it is proposed to do multi-level diving as well, it becomes a virtual impossibility to allow for all the complexities one has to start with a series of simplifications to even begin the process. It does not take or too many calculations to make a couple of simplifications.

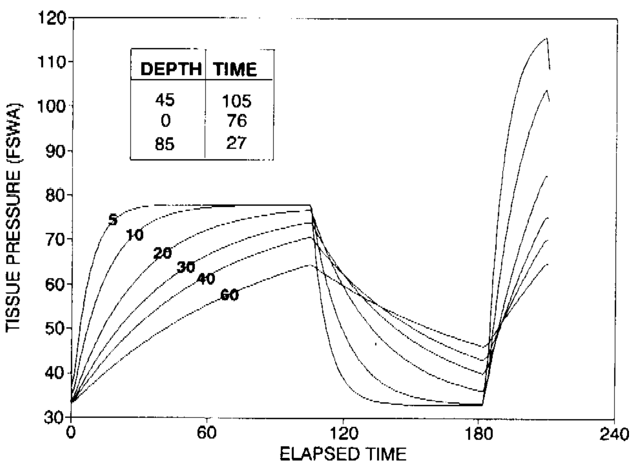

FIGURE 8

Tissue tensions in various compartments during two dives. The first dive is to 13.6 m (45 feet) for 105 minutes followed by a surface interval of 76 minutes with the second dive to 25.8 m (85 feet) for 27 minutes.

First, the permitted time at the second level is least if the depth at the first level is very close to the second. Secondly time is least at the second level if one goes to the non-stop limit at the first level. And if one puts these two together and makes a set of adjustmentsone has allowed for the worst case and all other possibilities are conservative.

We established a series of minimum depth differentials. We took groups of three depths and lumped them together into what we call a range of first depths, for example 140 feet through 120 feet make one depth range. We calculated what would be the maximum permitted depth for the second level, in this case 80 feet if one is in that first depth range. Table 2 shows the ranges and maximum depths of the second level. If one dives one's first level between 90 and 80 feet, one needs to go at least as shallow as 60 feet to be able to define it as a multi-level dive. Otherwise the old rule of total time at the maximum depth still applies. But if one can get a sufficient differential of depth then it can be called multi-level.

TABLE 2

RDP RANGE OF FIRST DEPTHS AND MAXIMUM DEPTHS OF SECOND LEVEL OF MULTI-LEVEL DIVES

Range of first depths	Maximum depths of second level
140 - 120	80
110 - 95	70
90 - 80	60
75 - 65	50
60 - 50	40

Step number two is to calculate the multi-level time adjustment. One does that by substracting the no-stop limit at the shallowest depth in one of these groups of three, from the no-stop limit of the second depth that would be permitted from the first depth range. This reduces the no-stop limit on each depth curve in such a way that no time does one ever go over the limit.

On the Wheel any curve out at the no-stop limit, marked as NDL, would be the normal amount of time permitted for a single level dive. But back up the curve of time is the multi-level limit, which says if one is doing this from deeper depth, and this is the second or third level of a multi-level dive, one is allowed a lesser amount of time.

All bottom times derived from the wheel will be more conservative than the theoretical model, but that is really not a problem, because the way it works out, air supply is generally insufficient for the time limits allowed for most of the multi-level dives.

Should we stop at 15 feet for 5 minutes?

Even two years ago this issue was controversial in the U.S.A. Why would one want to stop? Well, obviously one experiences a large reduction in tissue pressure at a very critical point in the dive. If one started off at 100% of the theoretical maximum one could make a 3 minute stop and in the 5 minute compartment one would theoretically be down to about 80% of what one started with. If one made a five minute stop one drops to less than 70 % (Table 3). This outgassing is pretty significant. Obviously in a slow compartment one does not get much change. However, most people seem to think that neurological injuries occur through a faster compartment bubbling and in these large benefits are gained from stops.

TABLE 3

PERCENTAGE OF MAXIMUM TISSUE PRESSURE AT STARTING ASCENT AFTER STOPS

Half-time	Percentage of maximum pressure	
	After 3 minutes	After 5 minutes
5	78.9	69.1
10	89.8	84.1
20	95.7	93.1
40	98.4	97.3
60	99.1	99.0
120	99.7	99.5

The next benefit occurs if one stays too long or goes too deep. Going too deep or staying too long are essentially the same thing. Why would one either? I do not know. Sometimes it is equipment failure. It happened to me once, when my gauge was reading 85 feet and everyone else had 100. It did not matter then because the dive was short, but if it had been to the limit I might have been in trouble. If we use good diving practices and make this safety stop as well, it can cover many sins. It is the cheapest insurance policy that there is.

The main reason is to slow ascent rates. We know that people ascend faster than 60 feet a minute. It is almost a physical impossibility to stop at 15 feet if one is going up at 150 feet per minute. So we are already ahead of the game if one has people thinking about the stop.

Once one has stopped, one begins to accumulate the other benefits I mentioned. Possibly the most important factor, is that when one is ready to leave the stop and go on to the surface, in the few feet of the water column where the pressure gradient changes most dramatically as far as volume ratios are concerned, it would be very difficult to get going very fast in those last few feet. So we will bring them back alive.

And I think we will see a significant decrease in barotrauma, in lung expansion injuries, neurological effects,and that a lot of them would almost disappear if everybody started routinely making stops. After all, it only takes three minutes of one's time.

The American Academy of Underwater Science (AAUS) met for three days in September 1989[8] to argue about safe ascents. We reached consensus on about 20 different issues, but the most significant, the issue that the AAUS felt was the most important, important enough to put on the cover of the proceedings, was that divers stop in the range from 10 to 30 feet from three to five minutes. But the details are not the important thing. The important thing is the principle is not stop where one wants to, but stop somewhere near the surface.

The Diver's Alert Network (DAN) as recently as December 1989[9] issued a whole series of recommendations and guidelines for recreational diving in general. DAN recommended that ascent rates should be no more than 60 feet per minute and slower is acceptable. Stop at 15 feet for three minutes, or more, for all dives. We go along with that. A decal was issued more than two years ago, with PADI's "S.A.F.E." diving campaign, with the introduction of the slogan "Slowly Ascend From Every" dive.

Slow compartments exist, supposedly, down to extremely long halftimes of 480, 600 and 720 minutes. They are probably important in saturation diving, but not in the ordinary recreational experience. Nevertheless, there are rules printed on the Recreational Dive Planner which require long surface intervals on occasion. These rules exist to deal with slow compartments and we will discuss the point in the next session, but some published commentary has, at least mathematically, exaggerated the importance of these compartments.

Table 4 shows a list of the tissues on the left hand side. A list of depths down the middle, and a list of times down the right hand side. They are the time and depth combinations required to pump the tissues up to the maximum for the theoretical amount of time that the model confers. Now, I really do not think that most people are going to stay for approximately a day at 24 feet, or more than that at 23 feet, but that is what it takes. So, for single dives, these times are obviously irrelevant. But it can become relevant if one is doing a lot of repeated multi-day diving.

TABLE 4

DEPTHS AND TIMES WHICH CAUSE MAXIMUM TISSUE PRESSURE

Half-time tissue	Depth (feet)	Time (minutes)
80	32	281
100	30	360
120	28	487
160	26	723
200	25	929
240	24	1,265
360	23	1,892

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This is an edited transcript of a lecture given at the 1990 Annual Scientific Meeting of SPUMS.

A companion paper "Testing the Recreational Dive Planner" also edited from the lecture transcript will appear in a later issue.

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THE DITAA SURVEY A REPORT ON A STUDY OF THE AUSTRALIAN DIVING INDUSTRY

Warrick McDonald

DITAA (Diving Industry Travel Association of Australia) is not just an organization to run SCUBA EXPO, the annual dive show where wholesalers, manufacturers and retailers exhibit their goods. DITAA takes its representation of the diving industry seriously and now offers members a wide spectrum of benefits. This survey is just one.

The survey was undertaken by Arthur Young and Company to benefit the diving industry through improved knowledge and understanding of the market and thereby help the industry along the road to greater success resulting in some cases in better profits.

Once one has analysed the contents of the survey one will appreciate just how valuable the information can be. If used wisely, the survey will enable the diving industry to plan and manage their businesses for profit. The information contained not only will benefit divers, dive shops, instructors, charter boats and wholesalers but other allied industries such as travel consultants, medical practitioners and printers of associated products.

The survey was commissioned by DITAA in order to provide, for the first time, information about the diving industry on a national basis. Little or no market research has been done for the diving industry in Australia. As a result it has been difficult for most operators to estimate the level and nature of demand for equipment and services. Retailers could lose in two ways if these demands are not known, either by having an inadequate supply of products from under calculation of current needs or by overstocking and possibly having to sell, at cut-throat prices, goods in an effort to reduce stocks.

The report of the survey analysed the current diving environment in Australia and discussed the study findings in detail. This paper will cover just a few of the points in the DITAA survey.

The Australian diving industry is affected by such things as population, external competition, customer lifestyles, technology, environment, overseas trends, the economy, internal competition and regulations. In 1981 the Australian population was 14.6 million, by the year 2001 it is estimated that the population will be 20 million. Also the age groups are changing. By 2001 28% will be 19 years old or younger while the 40-59 group will be 25%. From this the market will lie in the latter, "Baby Boomers", age groups and attention should be channeled into introducing them to diving. Customer lifestyles are towards family orientated,