PLANNING TO GO DIVING

Lesson Objectives

Before getting into the water on any dive there must be a plan to ensure the management of nitrogen in the body and that the diver has sufficient breathing gas for the planned dive.

Achievement Targets

At the end of this lesson students should

- Have a basic understanding of the effects of nitrogen on the body when diving
- Understand that management of nitrogen is crucial to minimise the risk of decompression illness (DCI)
- Understand the BSAC Decompression Tables terminology
- Understand how to use the BSAC tables to plan one dive and then two no-stop dives
- Understand the basic differences between tables and computers
- Understand that whether using tables or computers they are not infallible
- Understand the principle of the Rule of Thirds to plan and monitor breathing gas on dives

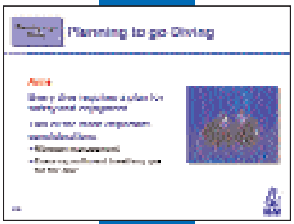
Following items will be needed

Copies of the BSAC 88 Decompression Tables to allow students to work with the Instructor on dive planning exercises. A dive computer to show as an example.

Following items will be useful as additional Visual Aids

A fizzy drink can or bottle to demonstrate fast release of gas bubbles

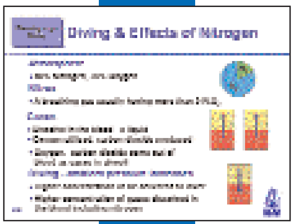
PLANNING TO GO DIVING



AIMS

Explain that before getting in the water

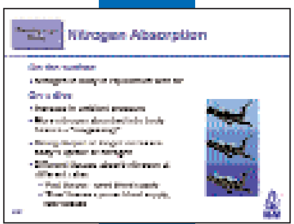
- Every dive requires a Plan for safety and enjoying a dive
- Two of the most important considerations in Dive Planning are
  - The management of Nitrogen in the body
  - Ensuring sufficient breathing gas for the dive undertaken



DIVING AND EFFECTS OF NITROGEN

Review with students what they were taught in an earlier lesson about.

- The composition of the atmosphere, approximately 21% oxygen and 79% nitrogen
- Nitrox breathing gases usually having more than 21% O_2
- Gases
  - Dissolve into the blood
  - Oxygen is utlised and carbon dioxide produced
  - Oxygen and carbon dioxide and nitrogen (17%, 4% and 79% respectively) are delivered back to the lungs and they pass into the alveoli in the lungs and are expelled to the atmosphere on exhalation
- When diving, as the ambient pressure increases, the regulator delivers to the diver breathing gas at the same pressure



NITROGEN ABSORPTION

On the surface, the body is in 'equilibrium' with nitrogen in the atmosphere, the body cannot absorb any more nitrogen. But on a dive:

- The increase in ambient pressure results in more nitrogen dissolving into the body This is known as nitrogen on-gassing
- Going deeper or staying underwater longer increases the nitrogen on-gassing
- Different tissues absorb nitrogen at different rates
  - Tissues that have a good blood supply, such as those in the brain or heart, absorb nitrogen quickly and are known as 'fast' tissues
  - Tissues that have a poor blood supply, such as bones, or have a high fat content, absorb nitrogen more slowly and are known as 'slow' tissues

Why is this a problem for divers?

NITROGEN RELEASE

During the ascent from a dive:

- As the ambient pressure reduces, nitrogen is released from the tissues – this is known as 'off-gassing'
- Just as nitrogen on-gasses at different rates, it also off-gasses at different rates
- The ascent phase of a dive is a relatively short period of time for the tissues to release nitrogen compared to the preceding part of the dive when the body has been absorbing nitrogen. So even after completing a dive and when the diver is back on the surface, the nitrogen continues to off-gas until it reaches a state of equilibrium with the atmospheric pressure - the body's 'normal' state

If a diver ascends too quickly:

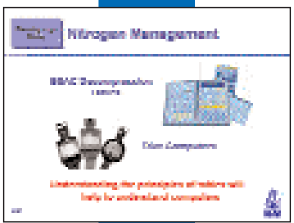
- The pressure of nitrogen in some tissues, or in the blood, exceeds the ambient pressure. The body can tolerate a certain level of excess nitrogen, but once this has been exceeded, the dissolved gas will begin to come out of solution by forming bubbles of nitrogen gas in the tissues or the blood

  (The principle of fast gas bubble release from a solution can be demonstrated, or referred to, with a bottle of fizzy drink. Open the top too quickly and in equalising the pressure in the bottle with the ambient pressure, bubbles can be seen forming in the liquid and rising to its surface)

- Most of the bubbles pass to the lungs and the gas is released through the alveoli. However, the presence of bubbles can slow down the off-gassing process and can distort or damage tissues or block the blood vessels. This can cause oxygen starvation to tissues downstream of the blockage. This is called Decompression Illness (DCI)

DCI will be covered in more detail in Ocean Theory Lesson 6 (OT6) but, obviously, it is to be avoided in planning a dive -

- It is the management of nitrogen absorption and release that is very, very important for divers



NITROGEN MANAGEMENT

There are two "tools" that divers use in planning a dive to avoid decompression illness

- Dive Tables
- Dive Computers

Both are mathematical "models" with inbuilt parameters that should not be ignored nor over-ridden.

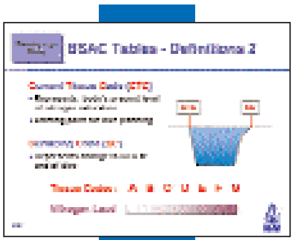
Although many divers now use computers, understanding the principles of tables will help with understanding computers.

BSAC TABLES - DEFINITION 1

To plan a dive using the BSAC Tables, some of the definitions need to be understood

- Depth - the deepest depth planned for the dive. Even if the intention is to spend only a small amount of time at the planned deepest depth, i.e. dive down to 18m on a coral wall and then rise slowly up the wall, the dive time is based upon the maximum depth of 18m
- Descent Rate - 30 metres per minute - most descents will be slower than that. This is a maximum figure not to be exceeded or it "throws" the table parameters
- Ascent Rate - 15m a minute - up to 6m. Ascent from 6m to the surface should take 1 minute
- Ascent Check Depth - Control of an ascent is very important in the management of nitrogen release. The last 10m is where there is the greatest pressure change. The ascent check depth of 6m is rather like a traffic light. Divers need to slow their ascent before the check depth to ensure fine buoyancy control at 6m and to where dive time is checked against the plan
- Dive Time - the time from leaving the surface to arriving back at the 6m check point

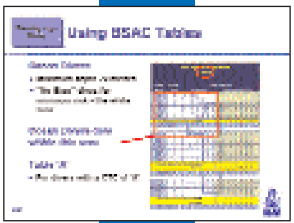
Students may hear the term "safety stop". This is where they may stop at 6m for a short period of time before ascending to the surface.



BSAC TABLES - DEFINITIONS 2

Other definitions relate to the theoretical level of nitrogen saturation in the body.

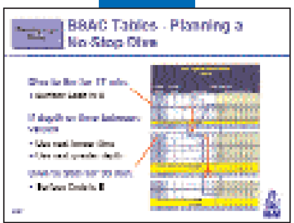
- Current Tissue Code (CTC) indicates the code given to the diver's "nitrogen" state at any time but is most significant at the start of a dive
- Surfacing Code (SC) indicates the level of nitrogen saturation at the end of the dive and this is dependent on the depth and time of the dive
- In the BSAC Tables the Tissue Codes are given as A, B, C, D, E, F and G. 'A' indicates the normal body surface tissue state before any diving has been undertaken. Further down the alphabet indicates an increased nitrogen saturation state. The SC will never be 'A' after a dive



USING BSAC TABLES

Ocean Divers are trained to carry out no-stop diving to a maximum depth of 20m using mixes of 21%, 32% and 36%. These dives must be planned using either BSAC ‘88 or BSAC Nitrox (21%) Decompression Tables

- Ocean Divers carry out "No-Stop" diving to a maximum depth of 20m. This is to introduce them to diving with minimum risk, enabling divers to perfect and be really comfortable with their buoyancy control on ascent before undertaking more adventurous diving
- Looking at the layout of the BSAC Tables, there are separate tables for each tissue code. Table A being used when the diver's current tissue code is 'A'
- The white area/zone of the table is what Ocean Divers will use, as this indicates No-Stop Dives. Ocean Divers are restricted to a maximum depth of 20m so it is only part of the white zone that needs to be concentrated on

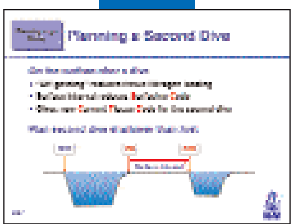


BSAC TABLES - PLANNING A NO-STOP DIVE

This is where the instructor, using the VA's can step the students through planning a dive.

Two examples are given on the VA, the first is straightforward and the second example demonstrates the need to use the next incremental figure if the depth or time falls between those noted on the table.

The Instructor will need to ensure students understand the principles of using the tables to plan one dive so by Instructor/Student interaction further examples may need to be given.

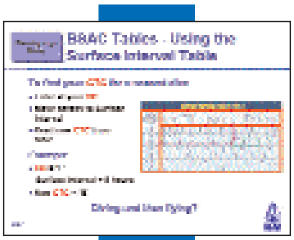


BSAC TABLES - PLANNING A SECOND DIVE

Going diving does not have to be limited to only doing one dive. A second dive can be planned using the tables.

- The diver is still off-gassing when they step out of the water at the end of the first dive. The Surface Code indicates the end of dive tissue nitrogen state
- The lower down the alphabet the Surface Code is, the higher the body's retention of nitrogen
- A diver will continue to off gas, gradually reducing the body's nitrogen state, for some considerable time after a dive
- The Surface Interval time affects the tissue code and will give a new start point, the Current Tissue Code, for the second dive. Using the surface interval table determines the current tissue code

However, when planning two dives, whether using tables or computers, divers should plan a shallower dive for the second dive.



BSAC TABLES - USING THE SURFACE INTERVAL TABLE

Using the Surface Interval Table

- Check the Surface Code from the last dive - as an example 'E'
- Check the Surface Interval from the time of surfacing from the first dive to the time planned for starting the second dive - as an example 5 hours
- This gives a CTC at the start of the second dive as B and Table B is used to plan the second dive

The instructor should give a couple more examples to ensure students can understand use of the Surface Interval Tables for planning the second dive.

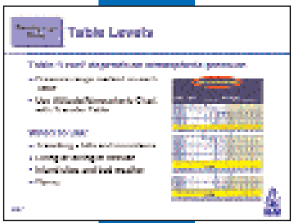


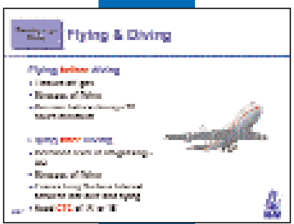
TABLE 'LEVELS'

Another important area to explain is the Table denominations of Levels 1, 2, 3 and 4. They reflect different atmospheric pressure ranges, shown in millibars, being progressively less than that shown on the Level 1 Tables. On and off-gassing is affected by a reduction in atmospheric pressure and the different table 'Levels' take account of this.

Point out to Students where the Altitude/Atmospheric Chart and Transfer Table are, as these need to be taken into account when:

- Travelling to and from dive sites over changes in altitude (high hills/mountains)
- Living or diving at altitude
- Diving protected sites at sea level when a low pressure weather system is present. This generally means planning dives on Level 2 tables
- Flying in pressurised aircraft where the ambient pressure is reduced - Level 4

NB. Where Branches/Centres need to use the Altitude/Atmospheric Chart and Transfer tables for their normal diving activities, examples should be given. If not, then this area can be covered more fully in Sport Diving lessons.



FLYING AND DIVING

Flying before Diving.

- All passengers' tissues off-gas while flying and, depending on the length of flight, take some time to return to their normal nitrogen levels. Diving after flying may seem a good idea as the nitrogen loading is reduced but flying has other effects on the body
- Most people will suffer from stresses of air travel such as disorientation, tiredness, nervousness, irritability and dehydration
- This can increase the risk of DCI so divers should not dive until they feel physically and mentally rested following a long flight

  A good interval should therefore be allowed to elapse between flying and diving - particularly for flights of less than 90 minutes in pressurised aircraft. This interval should be at least 10 hours

Flying after Diving.

Tissues continue to off-gas after a dive.

- Even in a pressurised aircraft, the reduced ambient pressure will cause any existing bubbles in the diver's body to expand or new bubbles to form. This greatly increases the risk of DCI
- Again, the stresses of air travel can have an effect on the body
- A good surface interval must elapse before flying. Due to the stresses of flying, it is strongly recommended that divers do not fly within 24 hours of their last dive

DIVING USING BSAC TABLES

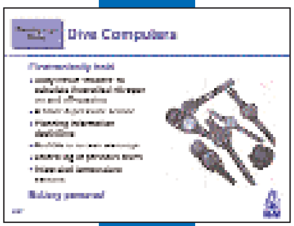
To dive the plan using tables, a diver will need

- A depth gauge to monitor depth
- A dive watch to monitor time
- A dive slate as a reminder of the plan

As with all dive planning:

- **Plan the Dive and Dive the Plan**

BSAC Tables or a BSAC Table Slide Rule are tools divers use to plan dives.



DIVE COMPUTERS

There are a number of models available. Divers must carefully read the instructions supplied with each computer and ensure they are acquainted with its operation before diving.

The basic functions of a dive computer are:

- To hold theoretical body tissue 'models' to calculate nitrogen on and off-gassing
- A timer and a pressure sensor, equivalent to a watch and depth gauge (Some computers calibrate to atmospheric pressure changes)
- Warnings are given either audibly or by flashing symbols on the screen, e.g. ascent to fast
- Pre-dive planning information - depth and maximum no-stop time indicated on a scrolling screen read out
- Previous dive information in a dive log, that can be recalled on screen
- Depending on the model, some have integrated water temperature sensors

The depth and no-stop dive time information, as with a watch and depth gauge, need to be monitored carefully.

DIFFERENCES BETWEEN TABLES AND COMPUTERS

For students' early diving, the main difference between tables and computer will be different no-stop times. This is because of the different dive profiles that tables and computers use.

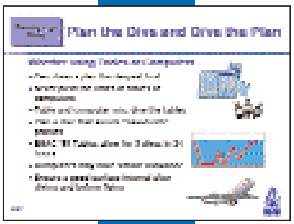
- **A Dive Profile**
  Is a simple tracking line of depth against time and is used as a simple method by divers when recording dives in their logbooks

  For example, on a wreck dive, the stern of a wreck has been chosen as the deepest part of the dive to then move up the wreck to shallower depths before the final ascent
- **Using a Dive Table**

  For the above profile, using the tables and planning for the maximum depth, the tables make no allowance for ascending to shallower levels and reducing nitrogen levels.
  - All timings are based on what is called a "square profile"
  - The table calculations assume the diver remains at the maximum depth throughout the dive
- **Dive Computer**

  Computers continuously update:
  - The actual depth of the diver throughout the dive as well as the time spent at all levels throughout the dive
  - The theoretical nitrogen absorption in each of the body tissue compartments for the actual dive undertaken

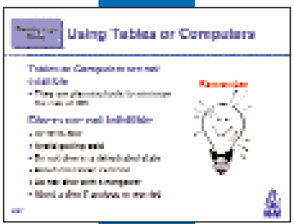
- With this information the computer no-stop time will be more generous than the dive table



PLAN THE DIVE AND DIVE THE PLAN

Whether using tables or computers the dive must be pre-planned and depth and time must be adhered to.

- Plan the deepest dive as the first dive
- Do not push the limits of tables or computers
- Where there is a mix of tables and computer in a buddy pair, the dive table should be adhered to being the more conservative of the two
- Avoid "saw tooth" dive profiles - these are "ups" and "downs" of more than 6m and compromise the mathematical calculations of both tables and computers
- Do not dive more than three times in 24 hours using BSAC ‘88 Decompression Tables
- Computers may have similar restrictions
- Ensure a good surface interval after diving and before flying

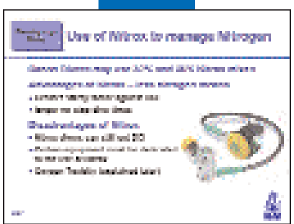


WHEN USING TABLES OR COMPUTERS - REMEMBER

Tables or computers are not infallible. They are based on theoretical tissue models. They cannot accurately reflect the real tissues of the diver using them

- They are planning tools to minimise the risk of DCI

  DCI can happen even when diving within table or computer parameters as other factors can affect a diver's predisposition to DCI.
- Be fit to dive
- Avoid getting cold - this may fall outside the parameters set for the tissue models.
- Do not dive if dehydrated - it alters the body’s fluid balance - particularly the blood which may clot around bubbles that may form. Dehydration is assumed to only affect divers in warm climates but, even in temperate waters, divers should ensure they have sufficient liquids before diving
- Avoid excessive exercise as it increases body stress levels
- Do not dive with a hangover. The effects of alcohol interfere with clear thinking so more mistakes will be made and it also dehydrates the body
- Abort a dive if anxious or worried



USE OF NITROX TO MANAGE NITROGEN

Nitrox mixes, because they generally contain a greater percentage of Oxygen, contain a correspondingly lower percentage of Nitrogen. This helps to reduce nitrogen absorption.

Ocean Divers may use these two common mixes - 32% O_2 and 36% O_2

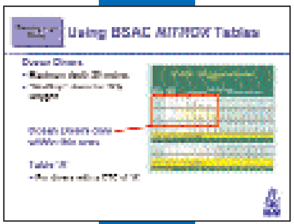
Advantages of Nitrox:

- Greater safety factor against DCI: Air tables and computers (air) assume 79% N_2, however, nitrox mixtures > 21% O_2 have less nitrogen, therefore giving less exposure to nitrogen.
- Longer no-stop times with nitrox tables and computers: The reduced amount of nitrogen means more dive time before stops are required.

Disadvantages of Nitrox:

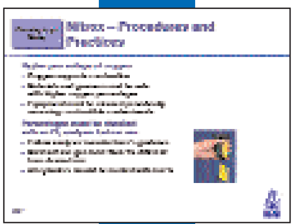
- Nitrox divers are still exposed to nitrogen. Staying overtime, rapid ascents, being unfit, drug/alcohol abuse, dehydration and all other normal causes of DCI cannot be ignored

- Certain equipment may be dedicated for the use of Nitrox in excess of 21%. This may mean additional expense for annual cleaning and certification (oxygen service)
- Care needs to be exercised that the dedicated equipment is not accidentally contaminated
- Some methods of cylinder filling can expose cylinders to 100% O_2. In such cases, cylinders must be in oxygen service
- Oxygen Toxicity: Increased percentage of oxygen in the breathing gas, may lead towards oxygen toxicity (explained later - OT6)



INTRODUCING BSAC NITROX TABLES

- Rules, procedures and definitions utilised in the BSAC NITROX decompression tables are the same as those used for the BSAC tables. It is therefore, essential that everything contained within the BSAC tables is fully understood prior to studying and working with NITROX tables.
- The layout of the NITROX tables are similar to the BSAC tables, i.e. there are separate tables for each tissue code, however, they apply to level 1 only.
- NITROX tables for level 1 have been developed for use with varying gas mixes. Air (21% O_2) table set, together with table sets covering three additional gas mixes, 27%, 32% and 36% Oxygen. The mixes are clearly water-marked as a numeric percentage on each table.
- The white area/zone on the 21% table is what Ocean Divers may use, as this indicates no-stop dives.



NITROX - PROCEDURES AND PRACTICES

Nitrox mixes (breathing gas mixtures > 21% O_2) contain higher percentages of oxygen; are more at risk of fire or explosion.

In order to reduce this risk (applies to mixtures above 40%):

Materials and greases used in the manufacture and maintenance of equipment used with Nitrox mixes must be safe when used with these higher oxygen percentages.

Equipment used with Nitrox mixes must be cleaned periodically removing any combustible contaminants.

There is a risk of Oxygen Toxicity, due to increased oxygen percentage, and according to the depth and time of the dive (explained further later). It is therefore essential that oxygen percentages are checked by analysing - both at the filling station, and then again just before the Nitrox mix is used.

In September 2006, a new British Standard BS 8478:2006 was introduced defining what diver grade oxygen and nitrox is and what the measurement tolerances should be for a particular range of nitrox breathing mixes. This defines the standard for commercially supplied nitrox. For general measurements on site, if analysis shows that the mix is more than 1% different from the mix desired, then the mix must not be used and the filling station requested to adjust the mix or refill the cylinder

Example: The desired mix is Nitrox 32

- Acceptable readings are between 31% to 33%. Outside this is unacceptable

When using Nitrox, all cylinders must be labelled with the % of oxygen contained and its MOD.

Avoid filling emergency cylinders with nitrox unless oxygen cleaned. The majority of emergency cylinders have been exposed to contamination by being left open. They are generally poorly maintained. The process of filling normally involves exposing the emergency cylinder to 200+ bar of direct gas pressure from the decanting cylinder, which leads to rapid increase in temperature. If contaminates are rapidly heated, there is a higher possibility of a fire or explosion, in the presence of enriched nitrox mixes

Using an oxygen analyser to analyse a Nitrox mix.

There is a wide variety of oxygen analysers available on the market, and the methods of operation of each are likely to differ, however, there is a generic principle of operation. The following is an example (by kind permission of Analox.com) of such a generic principle of operation. It is important therefore, to follow the manufacturer's instructions for the proper use of the instrument in each case.

Step 1: Switch on the gas analyser.

Step 2: Air Calibration. This is essential before use.

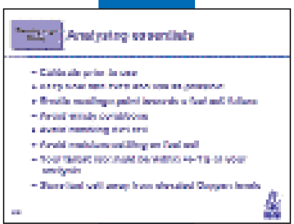
Step 3: Very slowly open the cylinder valve until the gas is heard gently hissing out.

Step 4: Present the analyser to the cylinder valve outlet and hold firmly to prevent gas escaping.

Close the pillar valve after a short period (this will depend upon the analyser type).

Step 5: Take a reading. Care must be taken here to ensure that the cylinder gas reading is taken and not the surrounding, ambient air.

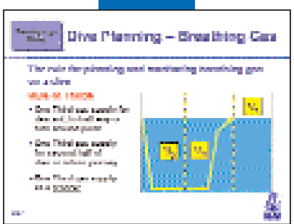
Step 6: Record the analysis



Observations, Hints and Tips

- Always calibrate in air prior to use
- Keep flow rate even and as low as possible
- Non stable or erratic readings points towards analyser failure
- Avoid windy conditions
- Avoid moisture
- Your analysis must be within +/- 1% of your target mix
- Store analyser away from elevated oxygen levels

Note: Although breathing gas suppliers are rigorous in controlling breathing gas mixtures, experience shows that it is possible for a mixture to be supplied which does not correspond to the cylinder markings or desired mix. All breathing gas mixtures should be checked on receipt and re-checked immediately prior to assembling aqua-lung kits.



DIVE PLANNING - BREATHING GAS

The diver must ensure that there is enough breathing gas for the planned dive. Not only should there be sufficient gas to complete the dive but there should also be an adequate reserve of gas in the cylinder at the surface.

For all divers; monitoring the use of breathing gas is crucial.

There is a simple rule that can be used for planning and monitoring the use of breathing gas on a dive.

- **The Rule of Thirds**
  - One third of the cylinder contents is used for the descent and half way or turn around point.
  - One third of the cylinder contents is used for the second half of the dive or return journey, including surfacing.
  - One third of the cylinder contents should remain as a reserve.

BREATHING GAS PLANNING

Using the rule of thirds is simple. Give the following example.

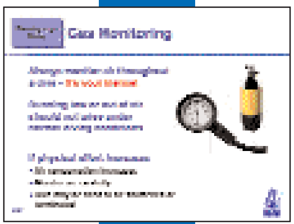
10 Litre cylinder filled to 210 bar

Divide 210 bar by 3 = 70 bar for each third

1. To calculate the turn around or half way point on a dive:
   210 bar - 70 bar = 140 bar
2. To calculate the second half and return to surface
   140 bar - 70 bar = 70 bar
3. This ensures a reserve of 70 bar at the surface.

This is a good starting point for new divers, but putting this into context, there may be instances where, depending upon depth, the reserve may need to be increased.

Using the Rule of Thirds, the instructor can give other examples to students



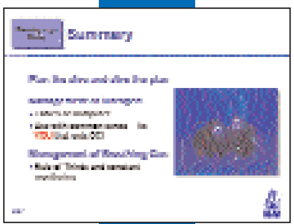
BREATHING GAS MONITORING

A happy diver is one who

- Monitors breathing gas throughout a dive - remember it is your lifeline!
- Running low or out of breathing gas should not arise under normal diving conditions - no matter how daft this may seem, this does happen

Monitoring breathing gas is also important because, if effort increases, or divers begin to feel cold or anxious the following may occur:

- Breathing gas use is likely to be heavier
- The dive may need to be shortened or terminated



SUMMARY

- To dive safely and enjoy the experience, divers need to 'Plan the Dive and Dive the Plan'
- This involves careful management of the effects of nitrogen absorption/release by using either tables or computers
- However, it must be stressed that they must be used with common sense - it will be you that gets DCI not the tables or computer
- As well as nitrogen management, divers must plan and manage their breathing gas supply. Divers can use a simple method called the Rule of Thirds but, monitoring the breathing gas supply is crucial for a diver's well being