fluids after about half of the ambulance journey. I was going to ask about cerebral oedema, but that question has been answered. Of course, this case also raises the problems about asthma and diving even if the asthma appears to be well controlled.

Question:

Why did you diagnose air-embolism?

Dr David Clinton-Baker

I think it was a diagnosis of assumption because he made a rapid ascent from 50 feet. There was no macroscopic evidence of pneumothorax. There was no emphysema. It was assumed that he had an air embolism. He never had any bronchospasm. There was a doctor on the boat, who auscultated his lungs and thought there were sounds on the left base but there was never any evidence of bronchospasm. He had inhaled salbutamol before diving. He had the salbutamol aerosol in his diving bag.

The bursting sensation inside his chest is the last thing that he can remember clearly. He thought that he ascended at a normal rate, but his buddies tried to attract his attention and they could not get any response from him. They both said that he ascended too quickly. But his memory of the accident is obviously quite blurry, and this feeling of an explosion in the chest may have happened after or during the last ascent. His memory is quite vague.

Question:

Should the absence of severe episodes of asthma for the previous three years indicate fitness to dive?

Dr David Clinton-Baker

I am sure that he had had virtually no trouble from his asthma, it had completely resolved by episodic inhalations of salbutamol for about four years.

But after this episode I would ask myself whether anyone who had a history of asthma requiring treatment is fit to dive.

Question:

There is no real evidence that he burst a bulla. Perhaps his asthma was co-incidental. Why did you diagnose an air embolism when he did not have a pneumothorax?

Dr Carl Edmonds

I am worried by the last question. Most cases of cerebral air embolism do NOT have pneumothorax or mediastinal emphysema. Why anyone should use the absence of pneumothorax as an argument against the diagnosis of cerebral air embolism is beyond me.

THE THEORETICAL BASIS OF THE US NAVY AIR DECOMPRESSION TABLES

Bruce Bassett

My topic is decompression. It is the area of physiology that I have spent most time with, starting with aerospace physiology and the problems of decompression of aviators and in later years, twenty years or so, getting involved with the diving side of it. I am going to discuss this and the theoretical basis of the US Navy tables and an analysis of their safety. In this first presentation, I will just cover the theoretical basis. My second talk is a proposed design for sport diver tables, and that is a natural offshoot from the safety analysis of the tables, so those will come together. The final presentation will be about the problems of flying after diving and diving at altitude.

I am going to limit my discussion to the US Navy tables. There is good reason for that, as the tables that we are using here in Madang, however they are laid out as sport diver tables, are all based on this standard. The US Navy tables are probably the most used tables in the world.

Your primary speaker next year is Brian Hills, who has another concept about decompression altogether. So I will be talking about the old historical stuff, while he will be talking about his theory and maybe the twain shall never meet.

US Navy diving tables are a masterpiece of design. They evolved over the years. They represent a cookbook for diving, with recipes for decompression. If you can read, you can follow these schedules. By design they have to be this way, they have to take care of the average layperson diver. You do not have to have a high school education or a university degree to understand them. If you follow the instructions they are pretty easy to use whether they are presented in the original format or in the sport diver format. The numbers are all the same. If you can follow instructions and if you can read, then you can follow the tables for decompression.

I like to go into the theoretical basis for the tables because it is somewhat obscure. Unless you can find somewhere the 1906 Journal of Industrial Hygiene from London, you do not find Haldane's original stuff. Haldane and Priestly published a textbook on respiration up until the 1930's, so you can find a little bit of this up to about then. The US Navy reports on the development of these tables, which was really just an offshoot of Haldane's stuff, are buried in the Experimental Diving Unit Reports, which are classified, and are not sitting around in most medical or other libraries. I will try to present in this paper a little about what Haldane found, why he developed what he did, and what the Navy did with that. In the next paper I will talk about the analysis of how good they are or how poor they are.

I do not like the term no-decompression, but that usage is very common (no-decompression is a dive that you never come back from) although no-stop diving is a better term. If we draw a graph of the no-stop limits, the “no-decompression” dives of the US Navy tables are to the left of the line while to the right are those dives which require stops on the way up. We are told, as sports divers, that we should never get into decompression dives. We should always stay to the left of the line. There are some implications in that statement that I am not sure are truly valid. However, I will discuss that in the next session. If we go to the right of the line, we get into the requirement for staged decompression. That is decompression stops on the way up. If you are strictly a sport diver, you may have never graphed out the profiles. But if you have studied the tables a little bit, you realise that as your exposure gets longer the decompression penalty, or the cost of your exposure, becomes progressively longer. For example at 150 feet for thirty minutes, you spend about an equivalent time in decompressing. For thirty minutes of play, you spend thirty minutes of boredom. If you spend eighty minutes at bottom at the same depth the time spent coming up is about two and a half times the bottom time. During this discussion of the theoretical basis of the tables, I hope it will become clear why this works the way it does. In decompression dives in the US Navy tables, the first stop is always short, and they get progressively longer as you work towards the surface. This is because of the basis of the model.

The basis of the US Navy tables is based on a concept of supersaturation and allowable supersaturation. The concept of the US Navy tables is that you can have a degree of supersaturation. So what is supersaturation? Supersaturation exists when tissue nitrogen tension or pressure exceeds the total barometric pressure acting on the body. In physiological shorthand PN_2 is greater than PB. You have to think about that one for a while to see how it exists. Some divers have trouble with this because they know about Henry’s Law. We know that nitrogen tension is only a fraction of the total pressure so how is it possible to have a nitrogen pressure greater than total pressure? Time is what is involved here. You go to depth, spend some time breathing compressed air, taking up nitrogen, increasing the nitrogen tension in the tissues, and then, particularly in the area of sports diving, you make a direct ascent to the surface. You have not spent as much time in decompression as you did exposing yourself to the increased nitrogen pressure. So you can, in fact, reach the surface with a nitrogen pressure in the tissues greater than the barometric pressure surrounding you.

That is a definition of the term “supersaturation”. The tables are based on allowing a degree of supersaturation. There are three ways of expressing this degree of supersaturation. It can be expressed as a ΔP which is an absolute pressure difference between what is in the tissue and the ambient pressure. It can be expressed as a M value, which we will get to later on, which is a sort of tabular relationship of inert gas over pressure. Or it can be expressed as a ratio. There is a maximum tissue nitrogen pressure which is tolerated at any given total barometric pressure. If you express this as a ratio, the ratio is equal to the nitrogen pressure divided by the barometric pressure.

I will elaborate on this point, because it is essential to the understanding of the way that the tables are built. If we have a man in equilibrium at any pressure, he is said to be saturated. So if we have not been diving for some period in excess of whatever time it takes to reach equilibrium, at sea level, we have nitrogen pressure of approximately seven tenths of an atmosphere dissolved in all the body tissue and fluids. The surrounding barometric pressure on our body is one atmosphere, so under these conditions, barometric pressure is greater than nitrogen pressure. We are not supersaturated. We are merely saturated. We are in equilibrium. If we take a man to a depth of 33 feet of sea water, ten metres, two atmospheres absolute, and leave him there long enough to reach equilibrium, his nitrogen pressure will increase to 79% of this total pressure. Again, so long as he is maintained at that pressure, barometric pressure is greater than nitrogen pressure, and he is merely equilibrated at a new barometric and nitrogen pressure. Now take this individual instantaneously back to sea level. He now attains the condition that we have to define, the state of supersaturation. Upon reaching the surface, he still has 1.58 atmospheres of nitrogen in all of the body tissues and fluids. The surrounding barometric pressure is less. It is 1 atmosphere. Now we have nitrogen pressure exceeding barometric pressure so he is supersaturated. If you wanted to express this as a ratio then it would be 1.9.

The concept of supersaturation that developed from Haldane’s time and then into the building of the Navy tables was that if you are at critical supersaturation or less, the excess nitrogen pressure finds its way via the circulatory system back to the lungs to be exhaled. So, as a function of time at the surface, you rid yourself of the excess gas. If you exceed the critical supersaturation relationship, then the force of excess gas pressure is great enough to cause the evolution of bubbles involving tissues and fluids. So that is the basic bubble theory as supersaturation describes it. It is essential to the way the tables were built.

By the end of the last century Royal Navy divers were having such a problem with decompression sickness, that the British Admiralty appointed a Commission to study the problem. The physiological representative on this committee was JS Haldane.

Haldane worked with the hyperbaric chamber at the Lister Institute. His primary animal model was the goat. Goats are still used in decompression research. They display bends quite nicely. I have done a little work with them in altitude studies. Haldane had a starting point when in 1900 he was appointed to this Commission, a starting point based on knowledge possessed by divers. The divers of the day knew that, if they did not have exposures greater than about 30 or 33 feet, for the times that they were occupationally exposed to, they had no problems when they came to the surface. They started to have their problems of decompression sickness when they exceeded this depth. It seemed to be a threshold depth.

Haldane's basic observations about decompression were based on this fact. He took his goats to a depth of 33 feet of sea water, 2 atmospheres absolute, which is a nitrogen pressure of 1.58 atmospheres. As best as he could estimate it, it would require his goats three hours to reach saturation, to become equilibrated at that pressure. By extrapolation, he felt that man would require about five hours to become equilibrated at that pressure or any other pressure. An important point here is that the time to reach saturation or any percent of saturation on this model, is the same regardless of depth. So that at 200 feet it still requires three hours for a goat to reach saturation. To reach some given percent of saturation (less than 100%) would require the same amount of time whatever the depth.

He took his goats down and repeated what was known at that time. He took them down to 33 feet and kept them there until he felt they were saturated, then brought them directly to the surface and found that they did not display any signs or symptoms or manifestations of decompression sickness. Presumably because they were not forming bubbles. If you look at the conditions that presumably existed the animals, if they were equilibrated, and they were pretty nearly saturated, had 1.58 atmospheres of nitrogen pressure in all of the body tissues and fluids. So when they hit the surface they were withstanding a ratio of nitrogen pressure to barometric pressure of 1.58-1.

The logical thing to do was to work the goats progressively deeper, saturate them and find out what the tolerance was to decompression. Obviously, if you were doing this scientifically, you would do it in stages. Haldane started at 2 atmospheres and gradually worked deeper. If we take the example of 5 atmospheres absolute, 132 feet of sea water, nitrogen pressure 3.95, keeping the animals there for three hours, until they were presumably saturated, he found that as long as he did not decompress them any shallower than 2.5 atmospheres they were fine. If he tried to get them any shallower they started to display symptoms of decompression sickness. So if you look at the ratio of nitrogen pressure to barometric pressure, under these conditions, it turns out to be the same ratio that he observed in the first series of animal exposures. He worked to a maximum depth of 6 atmospheres absolute, 165 feet. This relationship seemed to hold true throughout. As long as the animals were not exposed to a supersaturation ratio of greater than 1.58 to 1, they did not have any symptoms. That was his initial empirical observation which allowed him to start building some tables.

If you are at 5 atmospheres and you reduce the pressure to 2.5 atmospheres the total barometric pressure relationship is a two to one relationship, as with two atmospheres coming to sea level. So very often you will hear Haldane's finding expressed as the two to one relationship. But in fact the driving force for gas phase separation is the excess nitrogen or inert gas pressure compared to barometric pressure. This is the overpressure of gas trying to come out of solution. Normally the gas is breathed off in the lungs but if the pressure difference becomes too great, then the forces are such that gas phase separation occurs.

So Haldane's empirical observation was that there seemed to be a critical supersaturation ratio that could be tolerated. The next phase in the developing of safe decompression was to build some sort of decompression schedule from this. First of all from this observation you could assume that, whatever the pressure you were saturated at, it was safe to reduce the pressure by one half. If you were at 5 atmospheres, you could always come directly to 2.5 atmospheres, no matter how long you had been at 5 atmospheres. Then you would have to consider saturating at 2.5 atmospheres and then reducing that by half again. Eventually you would reach the surface that way. But that is not realistic. If in fact it takes three or more hours to reach saturation you would like to know where you stand in terms of percent of saturation at any given period of exposure time. So Haldane's next problem was how to estimate the rate at which you approached saturation, the rate at which you take up and eliminate nitrogen.

He had three major factors to consider and a whole bunch of other variables. We will just look at three factors that cause it to be a fairly complex job to estimate what percentage saturation you have under a given period of exposure at any given pressure. When you got to depth and started exposing yourself to increased inert gas pressure, you established a large pressure difference between the nitrogen pressure in the lungs and that in the tissues. This large ΔP, pressure gradient, causes a rapid initial uptake of the inert gas. The circulatory system carries inert gas out to the tissues as a function of time, so tissue pressure is increasing. You are exposed to a fixed nitrogen pressure so as a function of time, ΔP is decreasing. Which means that the rate at which you can expect gas to transfer to the blood from the lungs and from the blood to the tissues, would slow down. Initially with a large ΔP gas uptake would be rapid and as time went on and the ΔP decreased, the rate at which nitrogen uptake occurred would slow down. And all this says is that you would not expect a linear relationship between time and percent saturation. You would expect some sort of exponential relationship, where uptake was fast at first, slowing down as the pressure gradient decreased. That would be the physical consideration.

To complicate this a little bit, we also know that the solubility of the inert gas that we are breathing is different in different types of tissues. For example, nitrogen is five times more soluble in fat that in water. So if you have a great deal of fat, it will hold more nitrogen and, theoretically, this would take more time to reach a given degree of saturation. If we describe the decay of the pressure gradient as causing an exponential curve, we can visualise that we have at least two exponential curves. One that describes the nitrogen uptake in water and one that describes it in fat. The curve for fat being the curve with a shallower slope, taking longer to reach saturation than in water because fat holds more nitrogen. We all know that in the body there is no clear division into adipose tissue and water only tissue. Every tissue has a certain degree of fat in it. The proportion of fat in a given tissue is going to tell you that tissue has a different rate of uptake to another tissue.

It is not just a simple problem of two curves to consider, one for water and one for fat. It is a whole family of curves for nitrogen uptake and elimination.

If that is not enough to confuse us, then we have to consider the transport system for getting nitrogen to and from the tissues, that is the blood flow. The rate of delivery or removal of nitrogen is dependant on the perfusion of the tissues. If you look at the actively metabolising areas of the body in a resting man, things like the heart, brain, active bone marrow, kidney and thyroid receive 75% of output, yet they represent only 25% of body weight. At first approximation, ignoring the fat issue, we could say that this represents 25% of your nitrogen capacity. Yet you are servicing this 25% reservoir with 75% of your blood flow. You have got a big stream filling a small reservoir. In resting man skeletal muscle and adipose tissue receives about 25% of blood flow, yet is 75% or perhaps more of the nitrogen capacity. A very large reservoir being serviced by a small stream. So again we have got another two curves to interpose. In fact we really have a family of curves for all different areas of the body, related to the rate of blood flow, or the perfusion factor, as well as the percentage of fat in a given tissue or area of perfusion.

So, in 1906 Haldane had an empirical observation that you do not want to see a relationship of more than 1.58-1 in terms of excess gas pressure to barometric pressure. But you would like to know what percentage of saturation you have on a given exposure. What you seem to come up with, just considering three factors, is a whole family of curves. So how do you estimate where you are at the end of a given period of time and a given pressure, if you have got an almost infinite number of uptake relationships based on perfusion, physical factors and so on?

Well, in 1906 Haldane could not do it, and I am not sure that we can do it. So Haldane said “To hell with it, I can’t do it” and he established a mathematical model. Haldane used the half-time equation which describes an exponential curve. This is a nice way of building exponential curves. You can produce a whole family of curves in this manner, by assigning either estimated, measured or guess work units of time to this equation. The half-time equation says that in one unit of half-time you reach 50% equilibrium. A unit of half-time is not defined in seconds or minutes or hours, it is unitless. It is the time taken to reach 50% equilibrium. With radioactivity 50% of what you are dealing with is decayed in one unit of half-time. If you are dealing with nitrogen uptake or elimination, you will take up or eliminate 50% in one unit of half-time. In the second unit of half-time, you go 50% of the remaining distance as it were, or a total of 75%, and so 87.5% in three units of half time, 93.75% in four, and right up the line. Of course the equation says that you never get where you are going. If you only go half the distance with each step you never reach 100%. But you get close enough for government work and diving and things like that. In practical applications six units of half-time brings you nearly to 99% equilibrium. Generally speaking, beyond six units half-time, you consider a theoretical compartment to be in equilibrium with the inert gas pressure that you are exposed to.

Haldane, using this totally theoretical mathematical model, and an empirical observation that animals could tolerate an overpressure of inert gas, expressed as a ratio of 1.58-1, now had the ability to build a decompression schedule. Haldane assigned time constants, theoretical compartments, to this model to build his tables. He assumed that there was a vast component, a vast tissue, that would have a half-time of five minutes. That is one unit of half time would be five minutes, two units would be ten minutes, and so on. Then he had slower compartments with half-times of 10 minutes, 20 minutes and 40 minutes and the slowest compartment in his model was 75 minutes. So that compartment would reach 50% saturation only after 75 minutes of exposure. Nobody has ever proposed that there was a distinct anatomical distribution for these half times. The general terms of fast tissues, slow tissues, medium tissues have been bandied around.

In an exposure to 4 atmospheres of absolute nitrogen pressure for 40 minutes, we take the half-time of five minutes and divide the time of the exposure, 40 minutes, by that half-time and that gives you the units of half-time for that particular compartment. Forty divided by five is eight units. This tissue has been exposed with a 40 minute exposure, eight units of half-time. Remember that beyond six you consider it 100% saturated. So the 5 minute compartment in 40 minutes would have 4 atmospheres of nitrogen pressure. The ten minute compartment in a 40 minute exposure would be 4 units of halftime, so that we would have 93.75% of 4 atmospheres, close to 4 atmospheres of nitrogen pressure. The 20 minute compartment after 40 minutes of exposure, 40 divided by 20 is 2, has been exposed for 2 half-time units. That is it would be 75% saturated so would have a nitrogen pressure of 3 atmospheres. The 40 minute tissue with a 40 minute exposure, 1 unit of half-time, so 50% saturated, which is 2 atmospheres of nitrogen pressure. The 75 minute tissue would obviously be something less than 50% saturated.

The equation allows you to determine, minute by minute, second by second, or even millisecond by millisecond, the percentage saturation of these theoretical compartments as a function of time. After your exposure for 40 minutes, to four atmospheres you are ready to decompress. The 5 minute tissue has 4, the 10 minute tissue something less than 4, the 20 minute tissue has 3, the 40 minute one has 2, and the 75 minute one has something less than 2, atmospheres of nitrogen pressure. You head towards the surface. Haldane said that you can continue upwards until the nitrogen pressure divided by the barometric pressure is no greater than 1.58. The tissue which has the highest nitrogen pressure as a result of this exposure governs your ascent. You do mathematical manipulation to find out what factor you divide by four to give you 1.58 and that is the barometric pressure that you must not exceed on your ascent. That is how Haldane built the decompression schedules in 1906, based on an assumption of half-times and an empirical observation that the animals withstood this degree of excess gas pressure, this degree of supersaturation.

The deepest stop on the decompression schedule was a very short stop, because it was determined by the tissue with the highest pressure of nitrogen, which is always the fast tissue. Coming up from depth you reach a point where the five minute compartment has this critical ratio, so you come to a screeching halt. How long you have to stay there for that ratio to decay is determined by the rate constant, so the deep stops are always short because you are dealing with a fast half-time. You allow it to decay down to where it is safe for that compartment to make another ascent of 10 feet. Then you find that the next stop becomes a little longer, because the 5 minute tissue has decayed down to where it is not bothering you at all and now you are stopped by the next slowest compartment. As you get closer and closer to the surface, depending on bottom time, each stop is limited by one or two half-time tissues. As you get closer to the surface, you get slower and slower compartments. So the time that you have to spend at a decompression stop gets progressively longer, because the outgassing rate and the uptake rate are, in this model, equivalent. So it gets very lengthy. The longer that you are down, the more nitrogen you put into these slower compartments which is when the decompression profiles start to become disproportionate. The longer dives require progressively longer decompression because of the large gas flows into slower compartments.

In 1906 Haldane published his tables, and compared to what was going on before 1906, he solved a lot of problems. Prior to 1906, the decompression profiles were generally slow linear decompressions, as well as slow linear compressions. Much time in diving was wasted in getting to depth and getting back from depth and they were not solving the problems. Haldane introduced his tables and that seemed to solve the problems. It worked for a long time. I can not tell you exactly when the US Navy started diving using the Haldane tables but they did. They were satisfied with them for a while, but Haldane's tables were fairly limited in terms of the range of depth. He did not go beyond 165 feet or 6 atmospheres.

The US Navy had requirements to go beyond Haldane's tables in terms of depth and time. So working with the Haldane model, they started to explore beyond Haldane's tables and eventually produced a set of their own tables. I am not sure of the date of them, they were before the ones we now call the US Navy standard tables. Using the Haldane model, they produced a set of tables that were properly tested at the experimental diving unit to an end point of zero bends. If somebody bent they went back and looked at the model, found out which tissue had the highest calculated pressure in it compared to barometric pressure and did a little cut-back here and there. Then they tested again and if they got by with it that was an established schedule. Then it went out to the fleet. These tables that I am talking about are the old US Navy tables that were superseded back in 1955. If you come across them you should recognise them because they have an ascent rate of 25 feet a minute instead of 60 feet a minute. In the depth and time columns they had something starred which was called an optimum time for a given depth. In those days they did not have repetitive diving tables. For repetitive diving you simply added the total time of each successive dive.

In the 1950s the US Navy decided to look at the tables again. There were many factors involved, one of which was probably some percentage of bends cases occurring on the old tables, also scuba had come into the military hardware. Scuba although giving greater mobility is short on duration, so the only way to get work done was to build a repetitive dive system. So they had to go back to the drawing board, the Haldane drawing board, and generate new schedules of standard decompression tables and repetitive dive tables and exceptional exposure tables all about the same time.

The next paper will take you to the US Navy tables circa 1955. They found that they had to extend half-times beyond 75 minutes. Within the standard US Navy tables the slowest half-time considered is 120 minutes and that is also the basis of the repetitive dive tables. The exceptional exposure tables go up to a half-time of 240. In saturation diving I have seen some ridiculous numbers like 360 to 720 minutes used. It is beyond imaginable physiology to have a tissue that has half-time of 750 minutes. How can you provide enough oxygen for it to survive if that is the perfusion? The model starts to break down with saturation diving. Empirically it was found that there was a different ratio for different halftimes. That is what the current tables are based on.

You probably know more about the theory of anaesthetic uptakes and so on than I do and I am not sure that any half-time pattern model is a valid model at all. Things are too dynamic to handle by a half-time concept. There are different models, some work as well, some maybe work better. If you get conservative enough in your approach to decompression, then anything works. When you are working at a close edge it is interesting then that this model has as good a record as it does. I am not sure that we really know how to describe what happens with gas uptake and elimination in terms of diving exposure.

Navy tables are based on half-times for 5, 10, 20, 40, 80 and 120 minutes in the range of the standard tables. The repetitive dive system is based solely on the 120 minute tissue. The exceptional exposure tables include half-times of 120, 160, 200 and 240 minutes. Other models do not use half-times. The Royal Navy model is not based on halftimes. The Swiss tables are based on halftimes. The Canadian model, instead of having parallel compartments as in the USN tables is a series model, where one theoretical compartment bleeds into another, which complicates it. None of them are absolutely proven as being physiological. They are models by which they approach decompression, empirically tested.

Question:

How much fine tuning did Haldane have to do after he worked out his figures? How much changing did he have to do between the theory and when he actually ended up with tables?

Dr Bruce Bassett

The theory evolved from Haldane's empirical observations. He did not do a whole lot of fine tuning. The next presentation will show how the US Navy fine tuned it. From there is the practical side, how good are they, what do the statistics look like and, maybe, what is coming down the pike, maybe that will be next year's meeting with Brian Hills.

ANOTHER ALUMINIUM CYLINDER EXPLOSION

WARNING FROM SOUTH AFRICA
CYLINDER EXPLOSION INQUEST AND ENQUIRY

On 29th October 1981 there was an Inquest Enquiry held into the circumstances surrounding the accident on 18th March 1981 which involved JS Jolly. It was found that the aluminium cylinder which exploded had been damaged thermally due to excessive heat during a repainting procedure.

The investigation, held in the Durban Magistrate's Court, reminded those using or filling such cylinders that:-

1. Aluminium cylinders which have been subjected to the action of fire of exposed to temperatures in excess of 177°C must be condemned and destroyed. There is no reconditioning allowed.

2. Any aluminium cylinder which shows any defects in this regard requires verification by hydrostatic testing.

3. All concerned are advised, in their own interest, to adhere strictly to these rules.

(From Barologia Newsletter, March 1982)

DIVING MEDICINE IN DEPTH

Courses conducted by:
Human Underwater Biology Inc.
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September 18-26, 1982 BP-16/Fundamentals. Bonaire, the Netherland Antilles.

October 30-November 6, 1982. AP-8/Selected Topics. San Salvador Island, the Bahamas.

December 4-12, 1982. BP-17/Fundamentals. Roatan, Honduras.

January 22-30, 1983. BP-18/Fundamentals. Bonaire, the Netherland Antilles.

March 26- April 3, 1983. AP-9/Selected Topics. Bonaire, the Netherland Antilles.

April 23-30, 1983. BP-19/Fundamentals. Roatan, Honduras.

June 18-25, 1983. AP-10/Selected Topics. Roatan, Honduras.

August 13-20, 1983. AP-11 Selected Topics. San Salvador Island, the Bahamas.

Brochures for each course will be distributed approximately five months before the starting date. Early registrations are encouraged as space is limited at each location. To ensure a place in the course of your choice, write to Human Underwater Biology enclosing a deposit of US$50.00 per person. The full course deposit of $200.00 per person is payable within ten days of receipt of the course brochure.

A CURRENT STORY

Officials at an aquarium in British Columbia are said to have two one metre long South American electric eels in one of their display tanks. This Christmas they decided to combine salesmanship with a practical application of the special powers of their exhibits. They placed two electrodes in the tank and connected the circuit to include the lights on a Christmas tree near the tank. Each eel is said to produce 100 watts of power, rising to 300 volts if they are particularly agitated. While calmly swimming the electric output is steady. Power increases as they actively hunt.

The electric discharge from the Australian Electric Ray are said to provide one diving instructor (at least) with innocent (?) amusement. He will suggest that diving pupils touch such creatures in his diving area, then shows that he suffers no ill effects, having waited till the ray's charges are much reduced. Former students wait patiently for him to pick the wrong ray one day.