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EQUIPMENT ADVANCES AND THEIR IMPACT ON INSTRUCTION

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Introduction

The rapid rate of change in the types of scuba equipment available for the diver entering the sport today has created concern in many underwater educators. Thirty years ago the would be diver was faced with the prospect of learning to function underwater with the basic equipment, i.e. mask, fins, snorkel, tank, regulator, backpack, buoyancy control device, wet suit and a weight belt. The curriculum was designed so that the student was first trained in skin diving skills followed by the progressive involvement with skills to enable them to use underwater breathing apparatus.safely. The procedures that were taught assumed that conventional equipment (virtually all of the equipment looked and functioned basically the same) would be used throughout the students diving career. Changes in the size of the hoses used in two hose regulators, the addition of a non-return valve on the exhaust side of the mouthpiece, and improved breathing characteristics did not, in and of themselves, change the functional requirements of the equipment. The methodology, which was utilized with great success, was essentially the same for all of the training agencies. Virtually every diver was a well skilled waterperson before they became involved in diving and most had been breath hold (free) diving for a long time before they could afford to consider scuba as an alternative. The hard core of the diving community looked upon the "bubble machines" as a poor substitute for free diving skill and would rarely justify its use in water shallower than 15 m (50 feet) unless the project at hand required an extended bottom time. The skin diver simply put on a "tank" if there was a desire to stay under longer. We have gone from fairly simple equipment, that had a very straightforward utilization to a vast array of equipment. However, this has created problems. As the amount and the kind of equipment we wear has increased, we have not always paid close attention to what other kinds of burdens are being put on divers.

Browning said that "a man in armour is his armour's slave". We often forget that, we just keep adding pieces of equipment. How can we describe a diver ? A diver is someone with tunnel vision due to the mask. Then there is some kind of suit, to keep him warm, that is going to push water away from one's body. That in turn is going make one more buoyant. There is an elegant solution to that, lead around the middle, which makes one sink again. Then fins are put on, so one can not walk forward but can swim with some degree of comfort. Then about 45 pounds of a scrap metal is placed between one's shoulders and a series of air chambers somewhere around one's body. These are bound together with a series of straps. Then there are high pressure and low pressure hoses. A diver carries a tremendous amount of equipment. It is rare for a diver to have any kind of hydrodynamic shape. We are just a big blob of bumps and lumps, which in the terms of development of drag, creates an unnecessary level of work for the diver. It is necessary in these circumstances to have fins that are going to deliver an adequate amount of thrust. This is less a function of the fin than a function of one's own leg strength.

Changes

A major change in equipment technology and philosophy occurred in the late 1970's and early 1980's. This change was reflected in the proliferation of devices which offered a much wider choice of functional characteristics. There are now a lot of different sizes of equipment. Improperly sized equipment adds to the difficulty of learning to dive.

Snorkels

The snorkel was originally like a piece of garden hose. With one's face underwater a tube in one's mouth lets one breathe. Many years ago the snorkel that had caged ping-pong balls was introduced. At first everybody thought they were a great idea. Underwater the ping-pong ball floated up against the end of a tube, shut the water off and the diver could not inhale any water through the snorkel. Unfortunately if one turned one's head, the ping-pong ball floated out of the end of the tube and it filled up with water. Back on the surface the choice was drink a little or cough a lot. Not such an advance after all.

US divers have a snorkel which lets water run out the side if it gets into the top of the tube. It works very well. It is a very easy breathing snorkel, but it has considerably more bulk and drag than slimmer ones. Snorkels come now with a purge valve on the bottom. This works well if they are in place. If one of those snorkels is stepped on the exhaust valve can pop out. If you use it like that and come to the surface, put the snorkel in your mouth, blow hard and then inhale, you get a mixture of salt water and air that is incompatible with good health.

A snorkel should be comfortable. When we had the garden hose, there was no mouth piece nor bite bars on it. The airway was roughly the same size as one's own airway with a certain amount of dead space. Now a mouthpiece with bite bars restricts the orifice. The harder one bites on the bite

bars, the smaller one makes the space at the back of the tongue. It is important when breathing through devices with a restricted orifice to keep it loose enough in one's mouth so that one does not shut off one's air supply. If you bite off the tabs on the snorkel, that is a sign that you have a significant amount of stress.

When one bites hard on the mouthpiece, one is putting a great deal of pressure on the mandibular joint. If you have headaches or tired and sore jaws after a dive, look at the bite tabs and if they are well chewed, recognise that one can avoid the sore jaw by simply carrying the snorkel or the mouthpiece loose in one's teeth. Incidentally that is a sign of comfort underwater.

Masks

Masks are still an air filled space that we put over the eyes and nose. The fit of a mask is most important. When there were only several standard oval devices one was trying to find something that made contact all the way around the eye sockets and the nose. Today that has been changed. In a modern dive shop there may be 50 or 60 different sorts and sizes of masks on a wall. This increases the complexity of selecting the proper mask. Some years ago we evaluated the visual field of various kinds of face plates to try to determine how well one could see out of any given mask. With the oval face mask, if one pushed the tip of one's nose down, the glass got closer to one's eyes and as it did, it pulled the edge of the mask in and gave one a larger peripheral visual field.

Some modern masks not only push the visual field farther away but by putting windows on the side there is the opportunity to look out at right angles. In these masks the light coming in the side will reflect off the glass, this constant reflection can be annoying.

Fins

UCLA has been studying swim fins for almost 20 years. We have built some devices to test fins. We test fins by having people swim against resistance not knowing which fin they have on their feet. We put the fins on their feet after they are in position. They operate under a series of workloads. We monitor heart rate, oxygen uptake, carbon dioxide output, thrust levels and whatever seems to be reasonable at the time. We feel that we get a reasonably objective view of what fins do. In the beginning it was easy because there were just a few configurations and all were solid fins. Research has shown that the fin will turn on its side if one does not have enough strength to keep the fin perpendicular to the direction of movement. When it turns on its side it goes through as almost as a knife edge. One does not get much thrust out of it. So one can have an adequate fin, but if one does not have the muscles, one can not hold that fin in a position to push one through the water.

Fins with holes in them become more flexible, which may make them more comfortable as they require less effort, but do not push one along so well. A better way to comfort is to increase the strength in one's legs until one can handle the stiffer fin. Whatever fin one uses the longer, narrower, stiffer fin will provide more thrust If one is only going to swim occasionally with fins, then having a looser, more flexible fin is fine.

In the United States we are starting to see the utilization of much longer fins. These longer fins have some real advantages in terms of developing thrust with a drag dominated kick. Again it becomes important that one has sufficient strength to be able to use the fin correctly. In surf conditions these long fins do not work very well, the foot pocket makes a cup and when the surf becomes very turbulent it comes in through the heel pocket and will strip that heel back and pull the fin right off one's foot. One has to wear a device that will hold it on the foot.

The Force Fin is of great interest to me. People either swear by it or swear at it. Those who swear by it say that it is the most comfortable fin and that they cannot believe that anyone has made a better fin. We tested it. It came last every single time when compared to other fins. The reason that it does that is because the fin has the stiffness of a noodle, it bends over.

With all this, we are now back in square one because the US Navy back in the 1940s did a study of swim fins in which they said long, stiff fins would provide the most thrust if one has the strength in one's legs to push them !

Tanks

Tanks have also come a long way since I started. We started off by using carbon dioxide cylinders which took about 1,800 pounds per square inch (psi) pressure. They were 33 cu ft and they would last a while underwater. Then we had 72 cu ft steel cylinders taking 2,000 psi. Now we have aluminium cylinders of 88 cu ft and more taking 3,000 psi. Now evolution of the cylinder is the ability to put more pressure into smaller cylinders. Scubapro have on the market a 3,300 psi series. Tanks are available which will go up to 5,000 psi.

The increase in cylinder pressure requires compressors that can push the pressure higher to keep up with the cylinders. There is a move towards the European Din System, where instead of using a yoke to hold the regulator onto the tank, one literally screws the 1st stage into the tank valve.

Buoyancy Vests

In the 1970s vests became widely used and it became

possible to buy them at the shops. Most early vests were "acquired" from stocks of devices designed to operate in an emergency on a one time use basis or if one was very lucky, and knew a Navy diver, one might be able to win a Navy swimmer's vest. The individuals who utilized these however, rarely ever put air in them. One learned early on about the importance of proper weighting. If one is properly weighted one does not have to put a lot of air in these devices. A second reason was that when one used these devices, one always ended getting salt water in the inside, which corroded the mechanisms for the the CO_2 cylinders. Such mechanisms would wear out and have to be replaced.

The use of floatation vests resulted in a technique called buoyancy compensation which enabled the diver to add small amounts of air through the oral inflation device while underwater. The wet suits were quite thin and proper weighting of the diver was a fundamental skill. Most of the divers who used the new compensation devices rarely put air into them during a dive because it was not really necessary if one was weighted properly.

As the manufacturers provided vests designed for repeated use in salt water and as the inflation mechanisms were improved, the use of the vests became standard in most programs and training on the mechanics of inflating one's own and one's buddy's vest became a part of the curriculum. Because horse collar vests floated up away from the diver crotch straps were added and trainees had to learn to put the weight belt on last in order to provide a clear drop path.

Each year saw improvements such as larger mouthpieces and larger diameter hoses on the oral inflators, push button control, inflators power with larger, improved design vest configurations and changing locations for hoses and relief valves of various kinds. The instructors taught basically the same curriculum that they had been using before with some additional emphasis upon the use of the improved devices. Some efforts were exerted by the manufacturers to standardize the functional characteristics of the devices but with little success.

The most important thing with buoyancy compensation, is that one has to displace water. There were compensators with floatation at the back and floatation at the front and across the shoulders, all designed to float the person in an upright position with the head out of the water. When the head is out of the water, so are the shoulders and some of the buoyancy. The manufacturers started moving the buoyancy compensation down lower. By putting this air down closer to the centre of mass, providing adequate controls and hoses to be able to deal with the problems, one has something that looks really good on the showroom floor. However, they may have some additional difficulties, when we try to use the buoyancy compensator.

I have not been a fan of back mounted buoyancy because it floats one face down in the water. In a new device the way the buoyancy is put on the backpack, the weight of the tank brings on a righting moment that brings the person into a face up position. One can still float face down but it makes it a great deal harder. One can float face down with chest mounted floatation if it is not used correctly.

The amount of water one displaces is the significant issue. Some buoyancy compensation systems when fully inflated have 18-22.5 kg (40-50 pounds) of lift. The simple fact is that if one wants to hold 18 kg (40 pounds) of additional buoyancy on the bottom, one is going to need 18 kg (40 pounds) of weight , a very heavy dive buddy, an anchor or some other device in order stop you becoming a Polaris missile.

The evolution in the variety of jackets has been wonderful. However it has also increased the complexity of the training problem for instructors. Virtually all the different manufacturers have different kinds of control devices on these buoyancy compensation systems. They are a tool. The individual has to know how to operate that tool and so does the individual's buddy. One of the difficulties one runs into with all the infinite varieties. A friend and I took several pages out of SkinDiver and we documented where the dump valves were, where the oral inflation systems were, how the oral inflation operated, how the dump valve operated, whether or not it had a CO_2 device and whether or not it had any kind emergency deflation and inflation system, catalogued all these devices and their locations and we came up with hundreds of variations from one issue of SkinDiver Magazine.

This variety means that any time that one is going to dive with someone, one needs to check their equipment to see where and what kinds of controls they have on. You might go to help them and try to use a different set of controls which may aggravate the very situation you are trying to remedy.

As a human factors man I am glad to see a trend back to where we were before. Buoyancy compensators have got very big. Manufacturers are now starting to make them smaller. Seaquest will be coming out with a BC which has only one strap on the front, it has large armholes, it has buoyancy compensation that runs in two chambers down the back and some of it comes around on the side, closer to the centre of mass. It is very easy to get it on and off. It provides adequate buoyancy and is a very handy vest. It weighs about a third of what the larger devices do, so is handy for travelling.

I like this because of it gets back to a size that is appropriate for the amount of buoyancy one needs. I was once told that the British Navy is partially responsible for the large buoyancy compensation systems because their experts wanted a buoyancy compensator that would support a swimmer in a sea state four. If one is out in a sea state four, one needs more than a buoyancy compensator to get you out of

danger.

Regulators

Some twenty years ago, the single hose regulator entered the scene and as the diving population began seriously using floatation vests they began to enjoy the benefits of the single hose regulator. It is interesting to remember the controversy between the single and double hose regulators. Two hose admirers resisted involvement with the single hose configuration and the advantages and disadvantages of each device were expounded at length. Most training courses had both single and double hose regulators in the program and techniques for using both configurations were learned by the students. As the single hose configuration continued to be improved the two hose systems were phased out of standard training programs. Skills which were peculiar to two hose regulators were phased out and the curriculum stabilized for a number of years. The changes in equipment were largely cosmetic or at least consistent with the skills being taught to the classes.

The majority of regulators that are on the market today breathe far better than the best two hose regulator that was ever put into the field. However when the tank pressure is reduced to 300 psi, the majority of regulators are going to be unacceptable in terms of breathing at 36 m (120 ft). They become seriously modified in their breathing characteristics. If you then turn into a heavy breather at that depth the majority of regulators will not be able to support that kind of work load. In older regulators one got several breaths in a row that got progressively harder to breathe. With many of the modern regulators if you are pulling through a high peak flow rate, particularly at depth and with a low tank pressure, one breath be perfectly fine, the second breath you will feel resistance and third breath is going to be so very difficult that you may think you are completely out of air.

Regulators became available in a variety of configurations which included bottom, front and end mounted exhaust valves as well as adjusting levers and knobs and varying purge button locations. Now the number of auxiliary hoses which emanate from the first stage can very from one to five and often these hoses attach the diver directly to buoyancy devices, dry suits, and tools of various kinds with fittings which require a familiar touch.

With higher pressure cylinders we now have to re-engineer the regulator. Older regulators are not going to be compatible, even on some of the 3,300 psi fills. One of the things one should do is to make certain that the regulator that one is going to use is going to be compatible with the amount of pressure that one is going to put in it.

Alternate air sources

Alternate air sources now include the octopus, pony bottle, Air II, Spare Air, breathing from the BC and attaching a second stage to a low pressure hose leading to the inflator.

Protective suits

The modern wetsuit does an excellent job in keeping a person warm. Over the last twenty years the main change is that we have added colour and flexibility. In some cases we have sealed off the cuffs and the necks and made them drysuits. Others we have made very shining and sealed off necks and tops and provided environmentally isolated suits that can be used for diving in Sydney Harbour and places like that.

Drysuits have also come as shellsuits of very lightweight material, very easy to get on and off. These moves have also brought the same problems that I mentioned before. As we have increased the complexity of how these things operate, we now have now got to point where, in California in the last two years, we have had three, probably four, people die simply because they did not know how to operate the dry suit. In three of the four cases, they were experienced divers who said that it was “just another exposure suit and I’ll go out and dive my regular routine and everything is going to be fine” In each case at some point that individual had got head down. Air in water goes uphill, so it runs right up into the feet. The fins pop off and there are two legs kicking around on the surface. They all had air in their tanks, regulators in their mouths, were head down and could not get out of that situation. They breathed their air until there was no more. They all died.

It is now accepted that there should be a training course with every drysuit sold. In my view, with the complexity of buoyancy compensators systems and dive computers there need to be training modules with the specific requirements of each and every one of these new pieces of equipment. This need is putting a incredible challenge on our instructional programs.

Weights

Weight belts, and weighting systems associated with the life support system, took on new looks and locations. Unfortunately some did not work as planned.

Information systems

To avoid problems when diving we need to have tank pressure, depth and some kind of timing device. Today there are many devices on the market which are able to keep track of these three kinds of information. Information systems in the form of consoles with a variety of sensors and displays and dive computers with differing operational formats are also widely used.

One dive computer appeals to me. It shows a little tank that starts out full. As the dive progresses the little tank

gets empty. It has a little man that starts out empty, and the longer I stay underwater, the more the little man fills up. That concept made great strides in communication. It gives me all the numbers I need to do what I want, but what I need to know is that when the little tank goes empty it means that I have to go up. If the little man fills up that is very important information because that means you have to go up. In both cases it sends you shallower and shallower and back up to the surface.

Decompression tables

Although not in the category of equipment, it should be noted that decompression tables have proliferated to the point where confusion regarding acceptable bottom time, depth and safe ascent rate have increased the instructors' problems in preparing students to be able to make an informed appraisal of the calculated risk which the diver must face on each and every dive.

The present

The trend that had been set during earlier years has continued to operate as evidenced in the DEMA show. The appearance of new products and the improvement of existing products continues to flourish unabated. As a result, it becomes apparent that the instructor in the field, as well as the instructional agencies, must carefully analyze the impact of these changes upon their instructional programs.

The following indentification of areas of concern is presented with the hope that it will lead to a review of individual and group instructional programs.

A fundamental law of learning indicates that for better learning the instruction should move from the simple to the complex in a progressive fashion. It is also important that critical skills be overlearned and reinforced. Years of experience have not dimmed these fundamental concepts.

Buoyancy compensation is a critical skill made more difficult by problems associated with wet suit compression, the depth of the dive and the size and location of the "bubble" if it is contained in a compensating device. A common problem is the fact that many students have never learned the fundamentals of buoyancy control. They have not developed a sensitivity to the effects of small amounts of air added to the buoyancy devices and further have little appreciation of the complexities associated with maintaining proper buoyancy during the dive. Buoyancy compensation skills should be overlearned before the novice becomes focussed upon the push button capabilities of the device and neglects the art and science of control. It is unlikely that the characteristics of all buoyancy devices can be covered in a basic course, therefore, fundamentals of operation common to most devices should be stressed and detailed attention should be given to the device used in the course, never forgetting to inform the student that other devices may operate differently and any exposure to a device different than that trained upon, requires some additional training. The concept of additional training for any new situation, environmental or mechanical, is a building block for the appreciation of added risk.

It is fortunate that breathing regulators have retained their functional characteristics over the years. The ease of breathing has improved significantly and one result is a reduced lead time for the low on air feeling which used to be encountered at low tank pressure. It becomes increasingly important to have divers monitor their air supply in order to be at the end of the dive before they reach the end of their air. The student should also be aware that the more hoses they have coming out of the first stage, the more critical is the nature of the concern for monitoring air consumption. It is clear that air management skills must be overlearned. Any alteration in the easy pattern of a long steady inhalation followed by a long, steady exhalation should be understood as a signal that there is a need to evaluate the situation. Thirty breaths a minute is excessive. That person has already got problems. The use of awareness as a safety factor is an acquired skill which should be overlearned and reinforced.

I have addressed the issue of redundant alternate air sources in another paper. Suffice to say that the procedures for dealing with an out of air situation should be as identical as possible regardless of the type of equipment used. Familiar, overlearned skills tend to work in emergency situations. Unfamiliar, poorly learned skills tend to result in confusion leading to unsuccessful solutions. "When in doubt, sort it out".

Thermal protection has also changed rather dramatically and the use of thicker materials and dry suits of various types has resulted in the necessity for substantial changes in the instructional format. The thicker, more comfortable materials have resulted in difficulty for proper weighting since they require more weight to cause the suit to sink. Once the diver is underwater however the suit compresses as we would expect, but since it is thicker to start with it has a greater degree of change for each unit of additional pressure when compared to the thinner or more dense materials. This results in a twofold problem (a) divers tend to become overweighted in order to descend easily and their reliance on compensation skills becomes more critical and (b) at the end of the dive the diver has increased difficulty holding a neutral position near the surface for a safety stop. The use of ascent lines or increased dependence on the compensation skills are alternatives that require more training. Dry suits on the other hand, can be found in a number of configurations, each with its own characteristics. Neoprene dry suits are dramatically different from the "shell" type suits. The training requirements for effective use of dry suits has resulted in the development of independent training programs by some of the manufacturers. These programs are complete with video tapes and step by step instructional

packages which are essentially "stand alone" courses. A review of the course materials leads to the conclusion that specialized equipment requires specialized training of sufficient detail to develop a comfortable user.

A review of each of the categories of equipment appears to raise the same basic question for consideration by the instructional staff. Can the traditional "basic" course (regardless of what it is called) provide the necessary educational experiences to produce safe, effective, entry level divers who are comfortable with modern equipment? It may well be that the conscientious instructor can organize and extend the course to cover the equipment which they use in their course or they may train with less sophisticated equipment anticipating that the students, upon leaving the class, will seek training for the equipment that they ultimately choose to wear. It may also be the case that there will not be time available in the course to provide adequate training on the equipment .

The dilemma is of such a serious magnitude that consideration of alternatives seems appropriate. It is quite possible that the concept of a basic course will need to be modified so that modules for each of the more complex and specialized pieces of equipment can be fitted into an expandable curriculum. It is well known that individuals make remarkably specific adaptations to the demands that are imposed upon them. As a result, it is important to consider the specific requirements for each of the pieces of equipment that will be used and progressively expose the students to the use of the equipment, under realistic use conditions, while they are being trained. The students should be made aware that they are being trained. The students should be made aware that there is a learning curve with virtually every piece of equipment and that they have to make a personal decision to understand and execute the proper control for each piece of equipment they choose to use as a diver.

Conclusion

I believe that we have encumbered ourselves to the point where we are no longer able to operate as easily as we did before. It takes more training, more strength and more endurance to be able to dive effectively today than it did when the equipment was simpler. There is no way that we are going to be able to reverse the trend and go back to simpler equipment. We must recognise that for each piece of equipment that we put on our body, it is important to understand exactly how it functions in a given set of diving conditions and to become experienced with it to the point where we are completely comfortable. Also we must develop the strength and endurance to be able to use the equipment properly.

I believe that to design better diving equipment over the next 10 to 15 years we have to go back and take a look at what people do in the water and how they can do it better and more comfortably and what kind of training will they have to have in order for them to do it effectively.

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NATIONAL SCUBA QUALIFICATION COMMISSION BUOYANCY CONTROL INSTRUCTION

Terry Cummins

The National Scuba Qualification Commission (NSQC) is a Commission of the Australian Underwater Federation (AUF). It is a Commission composed of delegates of the AUF, the Federation of Australian Underwater Instructors (FAUI), the National Association of Underwater Instructors (NAUI), the Professional Association of Diving Instructors (PADI) and Scuba Schools International (SSI). The goals and objectives of the Commission are to:

1 Act as a review Commission for diving instruction and instructional standards in relation to the National Coaching Accreditation Scheme (NCAS).

2 Review the standards of those instructor agencies seeking NCAS Accreditation.

3 Act as an advisory body to the Australian Underwater Federation on matters relating to scuba diving and the National Coaching Accreditation Scheme (NCAS).

4 To have a public relations element so that it can act in support of the scuba diving industry in providing positive press releases as appropriate.

During the late 1980's when Standards Australia first started developing "Entry Level Recreational Diving Standards", the instructor agencies began to realize that they had much in common in relation to the teaching of a number of diving skills.

One of the most important skills that a diver has to learn is buoyancy control. Although slight variations may occur in the way the members of the National Scuba Qualification Commission may teach this skill, it is important to