PADI TEACHING ABOUT DECOMPRESSION SICKNESS AND HOW TO AVOID IT

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Summary

The population of recreational scuba divers is at an all time high, numbering in the millions. This year more entry level divers will be certified than ever before. The ability to produce a safe diver relies on the effectiveness of presenting the risks and how to avoid them to that diver, and subsequent demonstration by the student of mastery of this information. This is paramount to the reduction of the incidence of decompression sickness (DCS) in the field. In 1990 approximately two-thirds of the new entry level divers will be certified by PADI Instructors using an instructional system. The mechanism and philosophy of transferring information about decompression sickness, decompression, dive tables, ascents and computers to students and how PADI is meeting the responsibility of preparing todays diver to avoid the hazards of DCS into the 1990's is outlined.

Introduction

PADI is an international diver training association with headquarters in the United States and local area offices located in Australia, Canada, Switzerland, Japan, New Zealand, Saudi Arabia, Norway and Sweden. PADI's 28,000 members teach diving in over 80 countries internationally.

Our goal is to promote the training and education of the general public in the techniques of safe scuba diving. To do this we have established standards for the training of students in skin and scuba diving from entry level through the scuba instructor training.

Our methods of diving instruction are based on progressive training in the classroom, pool and open water. In 1989 PADI members trained and certified approximately 400,000 scuba divers. This represents approximately 70% of the U.S. market and an estimated 50% of the global marketplace. In 1990 this number is expected to increase.

PADI International believes that training and education are the cornerstones to diver safety. PADI is not interested in promoting a diving activity that might lie beyond the borders of safety. Our programs shape the thoughts, attitudes and behaviour of a significant portion of the diving community.

PADI Instructors teach entry level divers with an instructional system of diver education that is produced in metric and imperial versions and is translated into a variety of languages e.g.: Dutch, English, French, German, Italian, Japanese, Spanish and Swedish.

The ability to produce a safe diver relies, in part, on the effectiveness of presenting the associated risks of diving and how to avoid them to that diver, and subsequent demonstration by the student of mastery of this information.

In consideration of decompression education, this is paramount to the reduction of the incidence of decompression sickness in the field. A presentation of the mechanism and philosophy utilized in transferring information concerning DCS, decompression, dive tables, ascents, and dive computers to entry level diving students will follow. An outline of how PADI meets the responsibility of preparing todays divers to avoid the hazards of decompression sickness will be discussed.

The PADI System of Diver Education

When we design instruction and training programs at PADI Headquarters, many factors are taken into account. PADI standards and educational materials are based on considerations of student safety, learning, and enjoyment in addition to prudent instructor conduct. The safety of the diving public is considered first and foremost. Our goal is to train individuals who after completion of training have the skills and confidence to enjoy safe scuba diving without an instructor present.

The design of the PADI system of education follows a technological approach. Instructional technology emerged from the fields of psychology, neuro-physiology, systems design and computer science. The U.S. aerospace industry has used an instructional technology design approach to education for 20 years because of its ability to teach high tech skills efficiently in an environment of high costs and government accountability.

The technological approach to diver education is a process of planning instruction in consideration of bringing forth all the necessary conditions of learning. In education today, the most modern and effective means for providing training involves a systems approach. The PADI Modular Scuba Course, our entry level training system, utilizes this technological approach to education.

The Modular Scuba Course

The design of the Modular Scuba Course is objective driven using measurable performance requirements as criteria for success. Assessment items are derived directly from the objectives and performance requirements. These assessment items constitute our exercises, quizzes, exams and Knowledge Reviews.

A PADI instructor is a manager of instructional resources and uses the Modular Scuba Course system, adapting it to the needs and abilities of the student. Student

comprehension and mastery of information and motor skills are consistently measured.

PADI's educational approach is founded on the belief that maximizing effective instruction requires more than simply dispensing information.

Our systems approach takes into consideration how people learn and the proper guidance and preparation necessary that will allow virtually anyone with reasonable abilities to deliver effective instruction. However, the instructor must first have a high level of diving knowledge and know how to use this system, in addition to having expertise in dealing with student problem diagnosis. Our instructor development training process accomplishes the necessary development and training of these skills.

The Modular Scuba Course underwent a 10 month evaluation before receiving recommendation for college credit by the American Council on Education (ACE). PADI is the only diver training agency ever to receive this prestigious recommendation. ACE recommendation is based on the educational validity of our programs and our administrative capability to execute the educational goals we claim. We believe the ACE recommendations testify to the high educational quality PADI programs.

Component Parts

The PADI Modular Scuba Course system includes in part the PADI Open Water Diver Manual, The Open Water Diver Course Instructor Guide, Modular Lesson Guides, Quizzes and Exams, Audiovisual program and the Recreational Dive Planner.

The PADI Open Water Diver Student Manual is a teaching aid that approaches material at the same level and complexity as is discussed in class. It is important to understand its four unique characteristics.

The first is a controlled presentation of material. A carefully planned sequence of steps leads the diving student from a present state of knowledge to predetermined educational objectives.

The second is an incorporation of managed reinforcement. Learning is not left to chance, the learner actively participates by continually responding to questions. Immediate instructional feedback and correction is provided.

The third is a self-paced design. The learner can control reading pace and learning rate. The course is therefore able to accommodate students with a wide range of backgrounds.

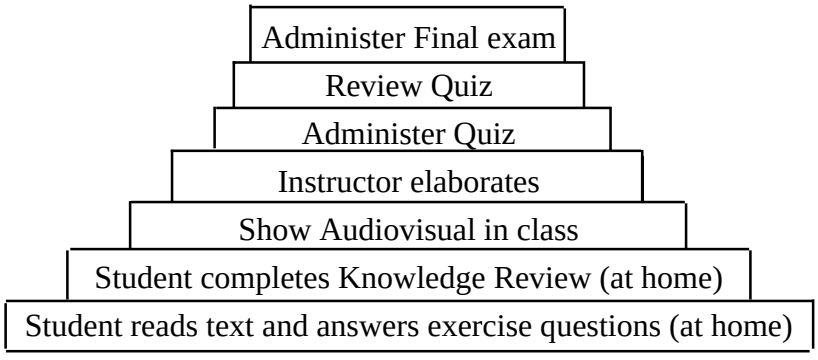
The fourth characteristic is learning efficiency. Diving information pertinent only to the objectives is presented. This programmed instructional approach assures increased student motivation and maximizes learning retention.

The other component parts enrich the instruction and combine to form the PADI Learning Pyramid. (Figure 1) Key diving information is reiterated at least 7 different times

FIGURE 1

THE PADI LEARNING PYRAMID

Essential information is reiterated seven different times using a variety of media



Maximum effectiveness is achieved only if the entire system is used as designed
TO OMIT A COMPONENT RISKS OMISSION OF ONE OR MORE "LEVELS" OF THE PYRAMID

using a variety of delivery methods. The student will read about decompression in the manual and complete the exercises in the book. The student will then complete the Knowledge Review at the end of the chapter. The student will then see an audiovisual tape reinforcing key points. The instructor will then deliver a lecture with overhead support elaborating on the concepts of decompression and answer questions. The student is then tested on recall and administered a quiz. The quiz is graded and reviewed with the student. Finally, at the completion of the course, the student is tested by a final exam to demonstrate mastery of this information. Advancement from one step to the next is determined by performance. The student progresses only when he demonstrates he has met objectives. Certification is based on demonstration of meeting all objectives, not how many hours he sat in class. This sequence assures that no important objectives or content is omitted while accommodating various student learning styles.

Decompression teaching

How does the Open Water Diver Manual guide students towards mastery of decompression information ?

The topical section on decompression sickness begins with clear student objectives that organize the instruction into relatively small sequential steps as reflected in the body of the text. The exercises that follow each section are based on the concepts of practice and reinforcement.

The objectives for decompression sickness an entry level PADI diver must master are stated in the Open Water Diver manual as follows:

"After reading this section on decompression sickness, you will be able to:

1 State the two primary factors that influence the absorption and elimination of nitrogen in a diver.
2 Name the condition that occurs when established depth and/or time limits have been exceeded, producing bubbles in the body during ascent.
3 List nine secondary factors that can influence the absorption and elimination of nitrogen from the body.
4 Identify eight signs and symptoms generally associated with cases of decompression sickness.
5 State the necessary treatment for a diver suspected of having decompression sickness.
6 Outline the first aid procedure for assisting someone with decompression sickness.
7 Explain how to prevent decompression sickness."

The text clearly describes the cause and effect of decompression sickness including symptoms. For example, the student is informed that "In the most severe cases (of DCS) unconsciousness and death can result". Perhaps most importantly, the student must demonstrate mastery of knowledge on how to prevent DCS.

In the topic section under Dive Tables, the entry level student is presented with the following objectives to master.

"After reading this introduction on dive tables, you will be able to:

1 State the primary use of dive tables.
2 Explain why the maximum limits listed on dive tables should be avoided.
3 Define repetitive dive.
4 Explain what is meant by no-decompression diving and decompression diving.
5 Explain why a diver's body nitrogen level is higher after a repetitive dive.
6 State one reason why the Recreational Dive Planner distributed by PADI is different from other dive tables.
7 Define bottom time.
8 Apply the nine general rules when using the Recreational Dive Planner.
9 State the maximum depth limitation for all recreational diving."

Throughout this section the student is encouraged to dive conservatively. An example, is found in the following:

"Be aware that although dive tables give you maximum limits, you need to dive conservatively, avoiding the maximum limits. This is especially true if any of the factors that contribute to decompression sickness (vigorous exercise, cold, older age, etc.) apply to your situation. Take extra precautions to not allow yourself to become dehydrated, for example, especially after several days of diving. Because people differ in their susceptibility to decompression sickness, no dive table can guarantee that decompression sickness will never occur, even though you dive within the table limits. It is always wisest to plan dives well within table limits, especially if any contributing factors apply."

This section also encourages an attitude towards slow ascent with a safety stop at the end of a dive. The PADI S.A.F.E.Diver (Slowly Ascend From Every Dive) philosophy is emphasized throughout. The diver learns to treat an ascent rate much like an no decompression limit i.e. to avoid reaching or exceeding it and to ascend slowly and take a safety stop for 3 minutes at 15 feet or 5 meters.

The specific student objectives for safety stops are:

"After reading this section on safety stops, you will be able to:

1 State the depth and time of a safety stop.
2 Explain the purpose of a safety stop.
3 Describe the three recommended situations in which

a safety stop should be made."

Additional information about decompression.

There are many other related areas of discussion regarding decompression in the Modular Scuba Course. For example, dive computers are discussed and the student is instructed to dive within the computer limits and always back up the dive plan with a table.

Entry level PADI divers are informed that dive tables and computers are mathematical models that approximate a physiological process and no matter how well designed or tested, they only approximate how the body absorbs and eliminates nitrogen. Divers are also advised to avoid decompression dives.

PADI has also adopted a strong position on insisting that divers be conservative with regard to multi-day repetitive diving. The following warning appears in the student manual and on the Recreational Dive Planner (RDP). "Since little is presently known about the physiological effects of multiple dives over multiple days, you are wise to make fewer dives and limit your exposure toward the end of a multi- day dive series."

Rules for flying or driving to altitudes after flying are also presented and must be mastered by the student.

The rules of use for the RDP reflect the conservative nature of our instructions. Recently, concern for deep repetitive diving emerged in the scientific community. PADI has printed the following additional rule on the RDP and educational materials to discourage this activity. "Limit repetitive dives to depths less than 100 feet/30 meters."

Instructor Education

The introduction of the RDP has made two major contributions:

1 an increased emphasis for dive planning and control,

2 a heightened decompression awareness educational campaign.

PADI has launched a decompression education campaign in its educational system as outlined, and also to our instructor members through our professional journals and training materials.

For example in 1990 we are teaching our instructors in the PADI update series to heed the following information:

A Make sure all of your students know that:

1 Even when tables are adhered to, divers have a statistical chance of contracting decompression sickness due to:
   a Biological variability. Each individual on this planet is different, hence there is a great deal of biological variability.
   b Imprecise decompression theory knowledge. In the real world, we actually know little about the dynamics of decompression; including bubble formation, etc.
   c Medical conditions. Just as there is variability between individuals, each individual has some amount of variability from day to day based on their medical condition.
   d Environmental conditions. Some environmental conditions (like cold water) can contribute to the likelihood of getting decompression sickness.
2 They can create their own trouble, by ignoring:
   a Their training.
   b Their table or computer.
   c Accepted safety rules.
   d Their dive pattern. For example, inappropriate dive patterns include "Sawtooth Dives" down, up, down, up, down, etc. and "Bounce Dives", making a short deep dive just prior to or just after a long shallow dive.

B As diving professionals, we need to foster a greater awareness of the importance of taking responsibility for diving intelligently. Divers should be advised that when diving, DCS is always a possibility.

C To help divers decrease their chances of contracting DCS while making repetitive dives on multi-day trips. Have divers:

1 Stay well within the limits of their table or computer.
2 When possible, wait 24 hours after a dive to fly.
3 Limit the depth of their first dive to 130 feet.
4 Limit repetitive dives to 100 feet or shallower.
5 Follow S.A.F.E. philosophy: Maintain neutral buoyancy, rise slowly (no faster than 60 feet/min. Treat this limit like an NDL) and make a safety stop at 15 feet for 3 to 5 minutes at the end of each dive.
6 Take a day off on day three or four when on a multi-day dive trip (this is a Divers Alert Network (DAN) recommendation).
7 Avoid making deep dives after shallow dives at any time during the multi-day excursion.
8 Begin each dive at the deepest level and move slowly shallower as the dive progresses (avoid "saw-tooth" and "bounce" diving)
9 Heed all rules and warnings for the RDP, regardless of the computer or table you use (the rules and warnings are generic and NOT RDP specific). Following RDP rules and warnings is always important.

Conclusion

Tables 1 (Certification Trends From 1978 To 1987),

2 (Number Of Fatalities Per Year 1970 to 1985) and Figure 2 (University Of Rhode Island Fatality Statistics)present data serving as an indicator that we are on the right track in diver safety and education. In terms of reducing the occurrence of decompression sickness, the number of reported cases appears to stay between 500 and 600 cases reported to DAN in the USA annually.

While the total number of dives being made is not known, it is likely to be increasing in proportion to the number of certifications issued. However, we can say that there are at least 1,200,000 dives annually. This is calculated by multiplying 300,000 new divers in the U.S. by the required 4 training dives giving a minimum of 1,200,000 dives. Assuming that there is no other diving of any kind, that is excluding active divers, this gives a worst case DCS/dive incidence of 0.05%. In view of the increasing number of divers a relatively stable occurrence of DCS may be a positive sign for the safety of scuba diving.

Decompression is highly complex. PADI is committed to decompression awareness and education. The more we learn about it the more definitive answers evade us. There are many variables to consider and divers need to be trained to take responsibility for themselves to avoid creating their own trouble.

PADI will continue to train divers to control their dive planning in consideration of their training in addition to keeping strong warnings and cautions on a variety of our educational materials.

TABLE 1

CERTIFICATION TRENDS 1978 - 1987

	1978	1980	1983	1987
PADI	70,000	130,000	190,000	340,000
All other agencies	150,000	110,000	120,000	135,000
Total	**220,000**	**240,000**	**310,000**	**475,000**

TABLE 2

NUMBER OF FATALITIES PER YEAR 1970 - 1985

Data on non-occupational scuba diving fatalities compiled by the University of Rhode Island National Underwater Accident Data Center Underwater Safety Project.

Year	Number of fatalities
1970	110
1971	112
1972	119
1973	125
1974	144
1975	131
1976	147
1977	102
1978	116
1979	130
1980	109
1981	103
1982	74
1983	110
1984	70
1985	76

Publications consulted

Richardson D. editor. *PADI Open Water Diver Manual.* Santa Ana: PADI International Inc.1988

DAN Report on 1987 Diving Accidents. Durham, North Carolina: Divers Alert Network, 1988

DAN Report on 1988 Diving Accidents. Durham, North Carolina: Divers Alert Network,1989

Scuba Diver Incidence Study. Tustin, California: Diagnostic Research,.December 1988

Cummins T. editor *Diving Accident Management in Australia.* Sydney: PADI Australia Pty. Ltd.,1988

Bennett PB and Elliott DH *The Physiology and Medicine of Diving* (3rd ed.). San Pedro, California. Best Publishing, 1982

The 1988 "Blueprint for Growth" Survey. Tustin, California: Diving Equipment Manufacturers Association, 1988

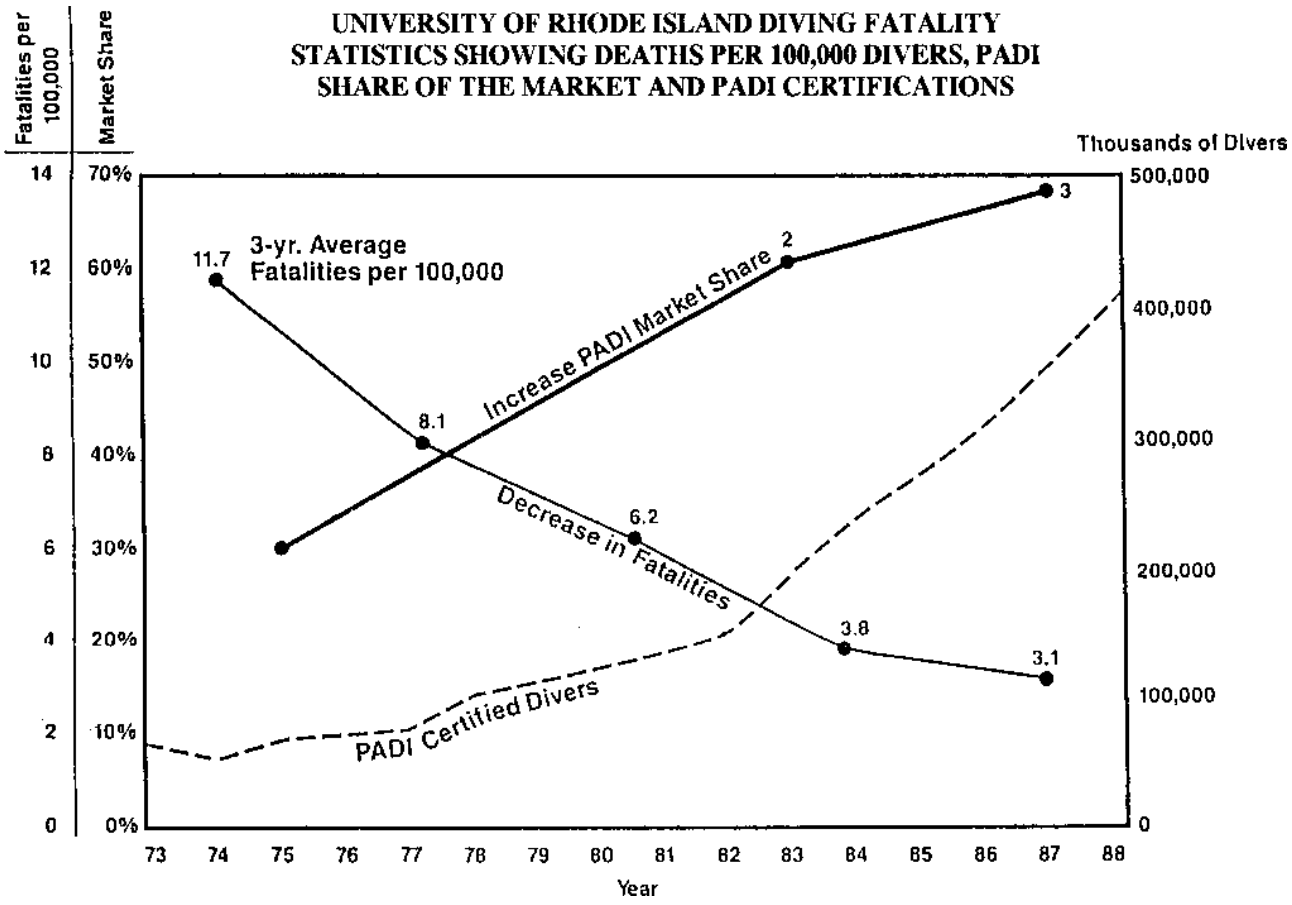
Richardson D. editor: *PADI Course Director Manual.* Santa Ana, California: PADI International Inc., 1989

Richardson D. How Much Diving Is Too Much? *The Undersea Journal*. 1990; 2nd Quarter: 14-15

Wohlers B. Brush Your Teeth After Every Meal And What Your Mother Would Tell You To do After Every Dive. *The Undersea Journal* 1990; 1st Quarter: 4-5

Richardson D. Taking Control of Dive Planning. *The Undersea Journal* 1989; 1st Quarter: 12-13

FIGURE 4



Sources of Market share figures for 1975 Bennett and Elliott “Physiology and medicine of diving”, 1983 DEMA certification census, 1987 calculated from “DEMA Blueprint for growth”.

Richardson D, Auditing Your Knowledge. *The Undersea Journal* 1989; 2nd Quarter: 3

Richardson D. A Word About Decompression, DSAT Research and Doppler. *The Undersea Journal* 1988; 4th Quarter: 12-13

Richardson D. Slower Ascent Rates: The PADI S.A.F.E. Diver Campaign. *The Undersea Journal* 1988; 3rd Quarter:5-6

Rogers R. Renovating Haldane. *The Undersea Journal* 1988; 3rd Quarter: 16-18

Wohlers B. A Brand New Manual for Entry-Level Students. *The Undersea Journal* 1988; 3rd Quarter: 2-3

Powell M. Unraveling the Mystery of Decompression Sickness, *The Undersea Journal* 1987; 4th Quarter: 6-7

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