

# Alert Diver

Digital Magazine

EUROPEAN EDITION

**Interviewing  
DAN's People**  
“Born under  
the sign of Pisces”

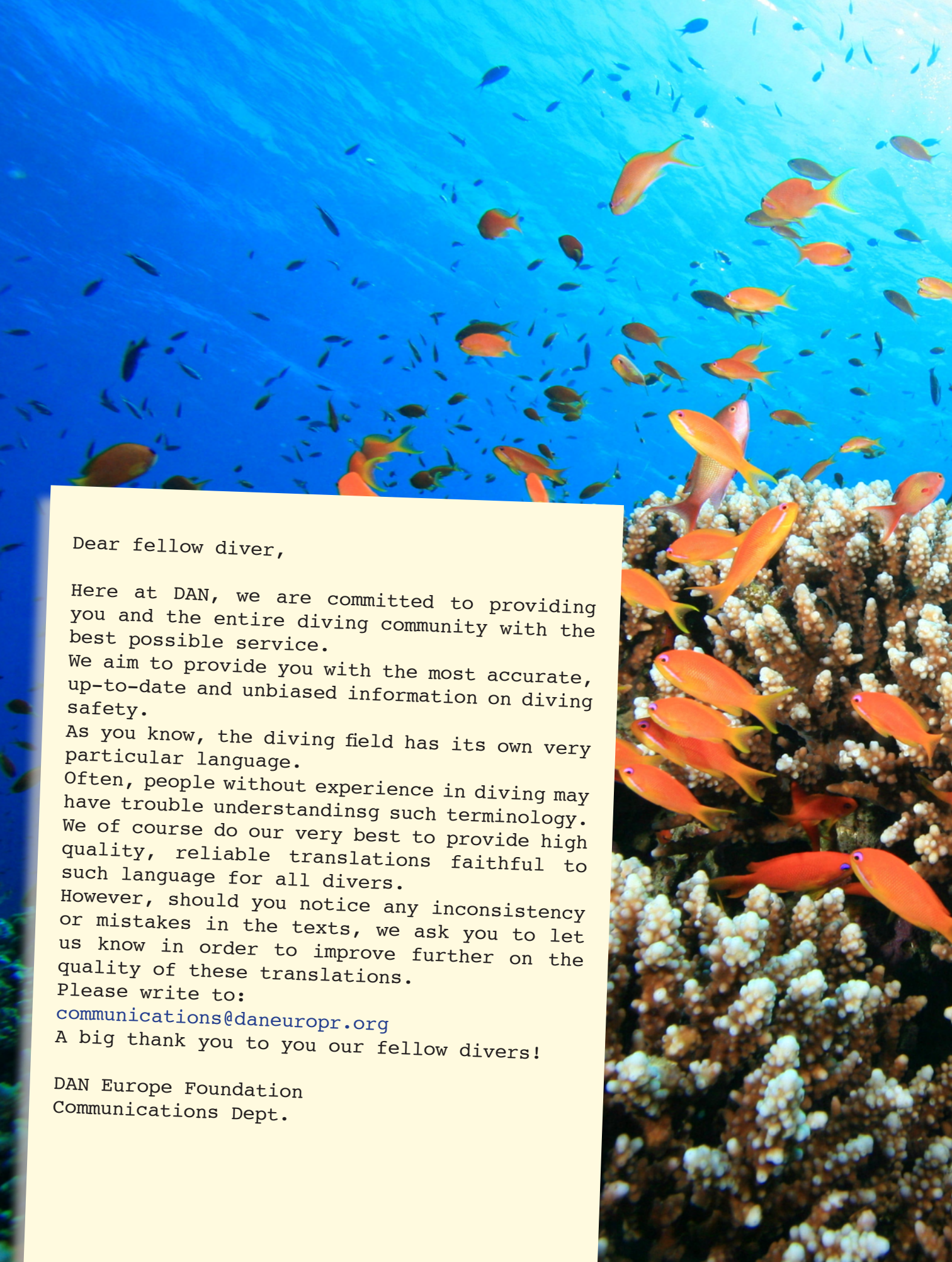
**Air versus  
Rebreather:**  
which one is  
best for safer  
diving?

**HIRA:**  
a new program  
for scuba diving  
service providers

**The “Kids as  
Dolphins” project**  
DAN Research and  
young breath  
hold divers

● *Prof. Alessandro Marroni, M.D.*





Dear fellow diver,

Here at DAN, we are committed to providing you and the entire diving community with the best possible service.

We aim to provide you with the most accurate, up-to-date and unbiased information on diving safety.

As you know, the diving field has its own very particular language.

Often, people without experience in diving may have trouble understanding such terminology. We of course do our very best to provide high quality, reliable translations faithful to such language for all divers.

However, should you notice any inconsistency or mistakes in the texts, we ask you to let us know in order to improve further on the quality of these translations.

Please write to:

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A big thank you to you our fellow divers!

DAN Europe Foundation  
Communications Dept.





# Alert Diver

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# COMING SOON TO A DIVE COMPUTER NEAR YOU

*by Dr. Saul Goldman and Ethel Goldman*

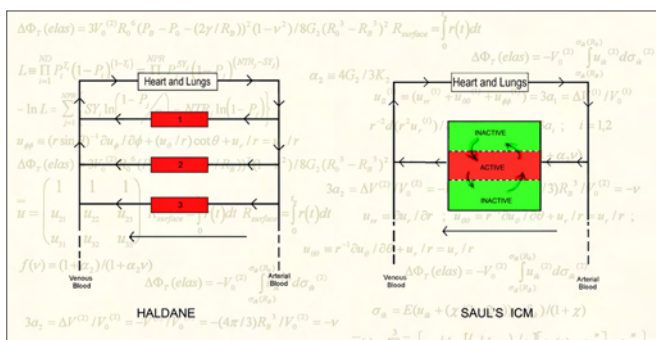
It's been twenty-five years now since dive computers came into general use. During that period of time a lot has changed, particularly in science and technology. Despite this, dive computers, at their core, have remained essentially unchanged. True, they now handle nitrox and trimix, and various "bells and whistles" have been added, but the algorithms underlying all dive computers currently marketed are still based on Haldane's model of independent parallel compartments, a model that has been around for one hundred years. ("No way!" you say. "What about bubble models?" Chill, we'll get to them.)

This wouldn't be a problem if Haldane's model worked really well. After all, sharks have survived essentially unchanged for eons and are considered, not as outmoded, but as a near-perfect design for their function and survival. Haldane's model isn't remotely in the same league. Its initial attractiveness was its relative simplicity. Suggestions for more realistic interconnected models were already around, and had been for some time, at the birth of the dive computer. But early dive computers were able to implement Haldane's model; a more complex model would have been too much for their memory and microprocessor capabilities.

Now, of course, we're in a completely different era where computing power and memory are concerned. And independent parallel compartments just don't stand up to scrutiny. A number of medical and physiological studies have examined the rates at which various substances, including gases, get distributed in and washed out from body tissues. The overall conclusion? The results were not consistent with Haldane's model, where the compartments were isolated from each other, but indicated that a more interconnected compartmental arrangement was likely

to be involved.

Here's a "heads-up" on a new interconnected model, one that will most likely be part of your diving future<sup>1</sup>: Saul's ICM. Figure 1 illustrates the basics of, on the left, a Haldane-type model and, on the right, Saul's ICM. Arrows indicate where gases can enter and leave compartments, so the differences in connectivity between the two models can be seen from the figure. A little less obvious is what the



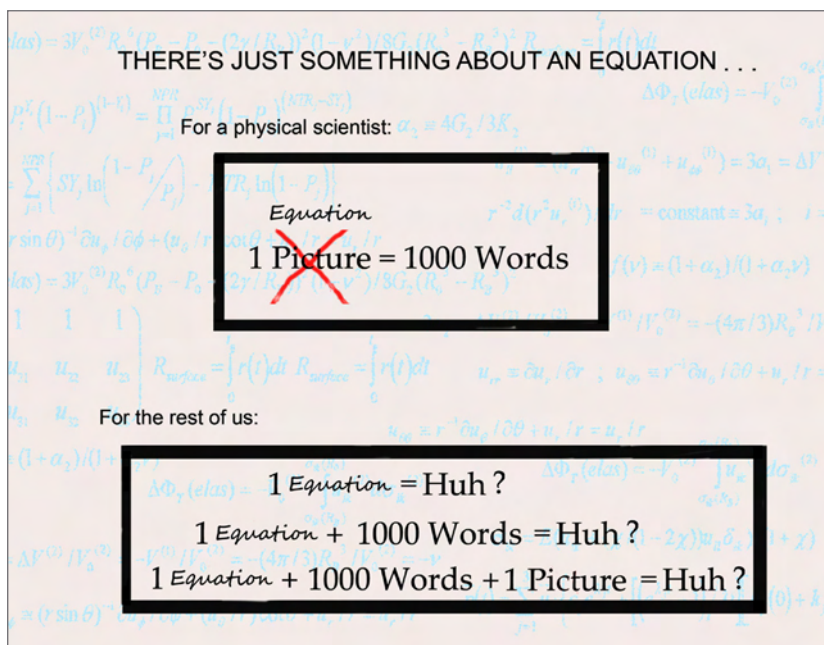
compartments in the different models represent. Each of the compartments in Haldane's model represents tissue that may give rise to decompression illness. (That's why all its compartments are red – for danger). Tissues that don't suffer decompression injury play no part whatsoever in Haldane's simple model. Although risks from all three compartments in a Haldane model are included in calculating the risk of decompression, in practice, the risk for any particular dive is mostly derived from the risk of only one compartment (the "controlling compartment"), with very little contribution from

the other compartments. On the other hand, in Saul's ICM model, only the central "risk-bearing" compartment (red) represents tissue with a risk of decompression injury; the remaining compartments (green) represent "inactive" tissues (such as fatty tissue) where decompression injury does not occur. Instead, their role in the model is to function as receptacles or reservoirs for excess gas. Initially, during compression, these tissues act like an overflow tank, increasing the amount of gas that can be absorbed without causing harm. But, as the dive continues and more and more gas is absorbed, remember that payback time will come. The dive will end and you will begin your ascent. The "overflow" gas has not disappeared. When you decompress, the risk-bearing compartment has to eliminate not only the gas already in it, but, in addition, the "payback" gas now returning from the other compartments. (This, by the way, increases the importance of slow ascents and safety stops.) Of course, in very low-risk dives, relatively little gas would be absorbed during compression, resulting in low concentrations of gas both in the risk-bearing compartment and in the other compartments. With a low concentration of gas in the reservoirs, the payback during decompression is very slow and, since the risk-bearing compartment is off-gassing its own low concentration of gas at the same time, the risk of DCS is less than it would otherwise be. All this makes a certain amount of intuitive sense when you think about how the body functions as a whole. But intuition has limited usefulness. The real test is in how well the model itself functions. And it's becoming clear that this model is far superior to existing models in predicting the probability of decompression sickness.

What, exactly, do I mean by this? Obviously, models aren't psychic. Here's how the comparison works. In practice, models are represented by sets of equations. At its core, an equation is just a sequence of mathematical operations performed using numbers in one of two ways: as variables or as constants. In diving mod-







ascents from saturation on air at 33, 40 or 50 feet of seawater (fsw). Let's see how different models, each calibrated on lower risk diving data, fare in predicting the results actually found. The graph shows some rather striking differences. The models we compared were: a typical Haldanean model; the LE1, Saul's ICM, and Saul's ICBM (a bubble-version of the Saul's ICM) models. The LE1 purports to add the effect of bubbles to what is otherwise a Haldanean model. Looking at the graph, we see that Saul's ICM and ICBM models are well in line with the actual results (which rise rapidly with saturation depth), while both the bubble-based and non-bubble-based Haldanean models maintain approximately straight-line trajectories which very seriously underestimate the

risks at greater depths. Adding bubbles to both interconnected and independent compartment models produces a relatively minor change in the predictions, while the effect of changing from an independent to an interconnected compartmental structure is huge.

What about comparing the models in the opposite, very low-risk direction, more typical of casual recreational diving? When we examine the incidence rate for about 10,000 dive profiles on air (from DAN's Project Dive Exploration [PDE] dataset), the interconnected models come closest to predicting the actual number of hits that occurred. These dives resulted in only 10 instances of decompression sickness. Doing some basic statistics on this, a model predicting anything between 5 and 18 hits would be reasonably on target. The LE1 model would predict 51 hits; a straight Haldanean model would predict 126 hits, the ICM would predict 10 hits and the ICBM would predict 11 hits. Again, the interconnected models outperform the others. So they are more accurate both with very high risk and with very low risk dives.

If you look only at the low-risk results, you may be inclined to yawn and wonder why you should care. So the existing models over-predict the number of hits - big deal. Doesn't that mean that they're more conservative than the interconnected models? And isn't that essentially a good thing, when it comes to staying safe? The answers are, respectively: "No" and "It depends."

Remember the very high risk comparisons we looked at earlier? The existing

## ABOUT THE AUTHORS:



**Saul Goldman**, a physical chemist, is Professor Emeritus at the University of Guelph and has published about 100 papers in some of the most prestigious journals in the field (see <http://www.chemistry.uoguelph.ca/goldman/>). Much of his research has dealt with liquids and solutions, particularly gases in liquids. He is also an avid diver who has logged almost 1000 dives. Since, like many physical chemists, he is somewhat “addicted” to equations,

**Ethel Goldman** became involved to keep the material suitable for casual reading by non-physical chemists and, in particular, to rigorously weed out equations and scientific jargon. When Saul insisted that equations were necessary, at least for background, Ethel “relented” but the only place you’ll find them is as background – literally.

models grossly underestimated the risk there. That means they are unsafe for these high-risk profiles. That in itself doesn’t matter too much, because you wouldn’t dive those profiles anyhow. More troubling is that their predictions didn’t follow the right pattern. This makes it likely that their predictions also seriously underestimate the risk in lesser, moderately high-risk profiles that you might consider diving. Is a more conservative model (which, as we have seen, does not necessarily describe current models) a good thing? Possibly, provided it’s an accurate one. The relative level of risk a diver is prepared to accept is a personal decision. But, without accurate information, you are not in a position to assess the true level of risk. Whether you want the safest option or whether you’re willing to tolerate slightly higher risks, the key to getting what you want lies in accuracy. Saul’s models can, as we have seen, provide much greater accuracy. (Obviously, this article could only provide a brief overview of the models and the research behind them. For complete details, and downloads of recent published journal articles, consult the author’s website.)

I expect that Saul’s models will be appearing in dive computers in the relatively near future and that they will eventually become the new standard for diving. Meanwhile, your best strategy is to continue to dive according to your dive computer, but be aware of its limitations. If it appears to conflict with something you may remember from dive tables or classes, take the safer option. And above all, never neglect your safety stops.

## REFERENCE

1. Goldman S. A new class of biophysical models for predicting the probability of decompression sickness in scuba diving. *J Appl Physiol.* 2007; 103(2): 484-493.



# COURSES OFFERED



## DAN Oxygen First Aid for Scuba Diving Injuries

As a recreational diver, you can receive training to provide vital first aid that can make a difference to a scuba diver with decompression illness. The DAN Oxygen Provider Course provides entry-level training in the recognition and management of possible diving-related injuries using emergency oxygen first aid. In DAN's most recent dive accident

record, less than 33% of injured divers received emergency oxygen in the field. Few of those received oxygen concentrations approaching the recommended 100%. DAN and all major diving instructional agencies recommend that all divers be qualified to provide 100% oxygen in the field to those injured in a dive accident.



## DAN Automated External Defibrillation (AED)

More than 10 percent of all dive fatalities are actually caused by cardiovascular disease, according to DAN dive accident and fatality statistics. This course teaches divers and other interested parties to provide care for sudden cardiac arrest including the use of an automated external defibrillator (AEDs).



## DAN First Aid for Hazardous Marine Life Injuries

Serious hazardous marine life injuries are rare, but most divers experience minor discomfort from unintentional encounters with fire coral, jellyfish and other marine creatures. This course teaches divers to minimise these injuries and reduce diver discomfort and pain.



## DAN Advanced Oxygen First Aid for Scuba Diving Injuries

This advanced-level program is designed to train existing DAN Oxygen Providers to use the MTV-100 (oxygen Resuscitator) and Bag Valve Mask while providing care for a non-breathing injured diver.



## DAN On-Site Neurological Assessment for Divers

Learn how to conduct a neurological assessment on a potentially injured diver in this course. The information gained in this assessment can help convince a diver of the need for oxygen first aid, and help a dive physician determine the proper treatment.



## DAN Medical Oxygen Rebreather (MO2R)

The DAN Medical Oxygen rebreather module supplements the DAN Oxygen First Aid in Scuba Diving Injuries course. Based on medical closed-circuit oxygen rebreather technology, a medical Oxygen Rebreather provides injured divers with high concentrations of emergency oxygen for extended periods. This training course instructs the Oxygen Provider in the use of DAN REMO2™ system.



## DAN Diving Emergency Management Provider / DAN Diving First Responder

Learn the knowledge and skills from several courses into one single approach to dive emergency management.

While the **Diving Emergency Management Provider** course combines the *Oxygen*, *AED* and *Hazardous Marine Life Injuries* course, the

**DAN Diving First Responder** course also includes the skills and knowledge from the *Advanced Oxygen* Provider course.

After reviewing the skills and knowledge development portions of this program, the students then participate in an integrated scenario where they get the opportunity to bring together all of the skills they learned in each of the segments into a single scenario.



## DAN Oxygen First Aid for Aquatic Emergencies

This course trains non-divers and professional rescuers (such as lifeguards) to recognise near-drowning / submersion incidents and other aquatic medical emergencies and to provide basic life support including the use of Oxygen.



## DAN Basic Life Support (BLS)

The DAN Basic Life Support (BLS) course will not only train divers and non-divers to resuscitate an injured person with a circulatory arrest, but can also prevent a person from getting in that condition. External bleeding, choking and shock can lead to severe circulatory and respiratory problems. The DAN BLS course will prepare you to react in the correct way, when accidents happen.



## DAN Diving Emergency Specialist (DES)

Continuing education is an important way for divers to continue to hone their diving skills and improve as divers. Divers Alert Network understands the importance of being an active and involved diver who takes the time to learn about not just new dive techniques, but techniques to care for yourself and others injured in a dive accident.

To recognise this commitment to dive safety, DAN has created a recognition program called Diving Emergency Specialist. The DES designation is a way to commend divers who have sought out the training they need to be prepared buddies and safer divers.

Ask Your DAN Instructor or visit the DAN Europe website for more information about this recognition program.



## DAN First Aid

The DAN First Aid course is an "add on" to the DAN BLS course. This programme combines many First Aid techniques for minor and serious injuries and includes:

Injury assessment – Illness Assessment – Splinting Techniques – Wound treatment and bandaging – Moving injured persons – Heat Exhaustion and heat stroke – Hypothermia

# DAN Mission Statement

Divers Alert Network (DAN), a nonprofit organization, exists to provide expert medical information and advice for the benefit of the diving public. DAN's historical and primary function is to provide emergency medical advice and assistance for underwater diving accidents, to work to prevent accidents and to promote diving safety. Second, DAN promotes and supports underwater diving research and education, particularly as it

relates to the improvement of diving safety, medical treatment and first aid. Third, DAN strives to provide the most accurate, up-to-date and unbiased information on issues of common concern to the diving public, primarily, but not exclusively, for diving safety.

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