

SCUBA DIVING: HOW HIGH THE RISK?

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Introduction

For most scuba divers, the excess mortality risk is fairly low. The best estimates suggest that the risk is four deaths per 100,000 divers. The least risk for diving accidents is in those experienced divers who are participating in only non-technical dives, are reasonably fit with no serious health problems, and do not have a history of being risk takers.

Underwriting scuba diving risk has been a challenge for most insurance companies. Although there may be as many as three million recreational divers in this country, there is limited classical medical research on the mortality and morbidity of diving. In addition, there is no national register to supply reliable data on the total number of divers or dives made per year. This lack of valid numbers for divers and dives (total exposure) means there is no denominator with which to compare the number of reported accidents and fatalities. True incident rates and, therefore, true mortality ratios remain elusive.

Estimated mortality and morbidity figures for scuba diving

In the early 1990s, the National Sporting Goods Association surveyed 20,000 households for their participation in various sports.¹ The results suggested there were two million active scuba divers in the United States. Those data were matched to reported injuries by the National Electronic Injury Surveillance System (NEISS). NEISS surveyed 85 hospital emergency rooms and from this small sample estimated that nationally there would be 1,400 scuba diving injuries. Their combined reports suggested that for two million divers, there were 1,400 injuries for an incidence rate of injury of 0.07 percent. This compares to rates of injuries for swimming and water skiing of 0.17 percent and 0.24 percent, respectively.

Some scuba experts believe there are only a million active divers. However, during the 1980s scuba diving was one of the fastest-

growing sports. Agencies reported training as many as 300,000 new divers each year. Not all divers remain active; and even if as many as 100,000 divers drop out of the sport each year, it would mean there are between three million and four million divers, not one million or two million. If the higher numbers are more accurate, the incidence of injuries is closer to 0.04 percent to 0.05 percent.

In 1993, the ratio of deaths to accidents was 1:10.² This means that the best estimates available give a ratio of four deaths per 100,000 divers per year. A group in New Zealand estimated a similar rate of injury.³ They considered 10 as the average number of dives per diver. If this number is reasonable for active US divers, the mortality risk for scuba diving is 4-5 per 1,000,000 dives. Obviously, scuba diving is not as high a risk sport as many believe. While scuba diving is a small added risk to the general population, insurance companies are, nonetheless, interested in identifying those individuals in whom the risk might be excessive.

DAN as a source for reliable data

Since 1989, the Divers Alert Network (DAN), a non-profit organization affiliated with Duke University, has been collecting injury and fatality data for scuba diving.^{4,5,6} Reporting accident data is voluntary, but DAN has been able to collect information on most fatalities and many accidents involving American divers. DAN research assistants try to follow up with victims, witnesses, and medical authorities to fully characterize the circumstances of every accident brought to their attention.

Figure 1

Summary of Estimated Rates of Injury and Death Based on NEISS Injury Rates

Number of Divers	Number of Injuries	Rate of Injury	Rate of Death
1,000,000	1,400	.14%	.014%
2,000,000	1,400	.07	.007
3,000,000	1,400	.04	.004
4,000,000	1,400	.035	.0035

Figure 2

Total Accidents Reported to DAN
(Adapted from the 1993 DAN report with permission)

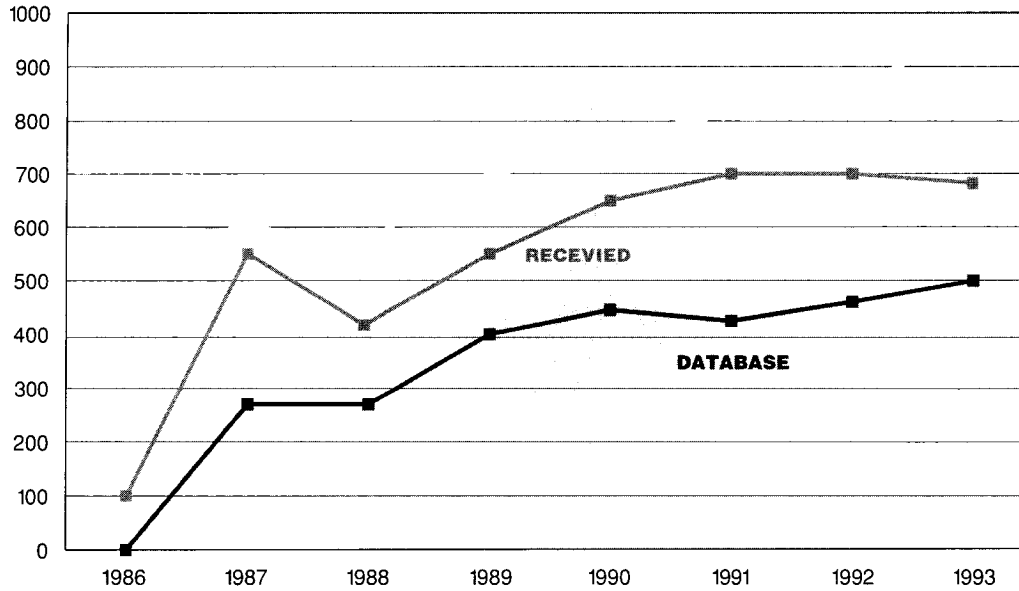
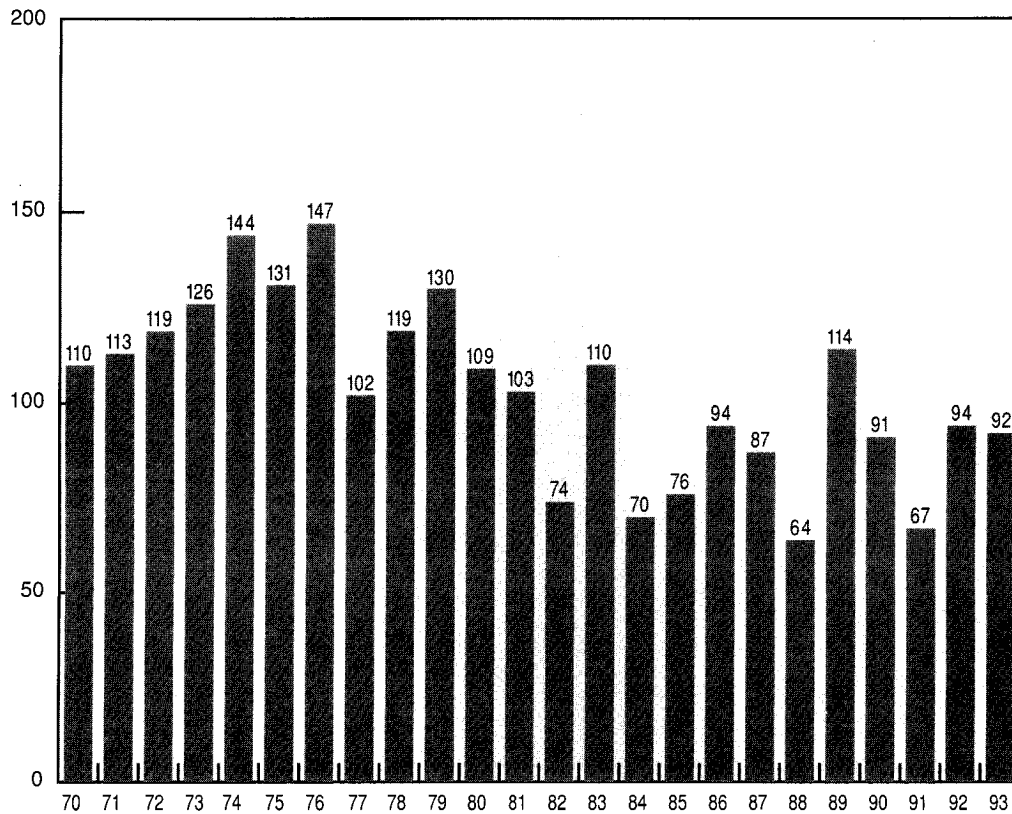


Figure 3

Fatalities Reported to DAN for US Divers 1970-1993
(Adapted from the 1993 DAN report with permission)



Besides data collection, DAN's mission is to educate the public and physicians on diving health and safety issues and to provide emergency assistance for the evaluation, transportation, and treatment of injured divers. DAN has developed sister organizations worldwide; they include DAN Europe, DAN Japan and DAN Australia. This means that wherever American divers suffer injury, their accidents are likely to become a part of DAN's data base.

As more governmental agencies become aware of DAN's mission, more accidents are reported (See Figure Two). In 1993, there were 958 accidents reported with 92 fatalities. Compared to 1992, this is an increase of 7.8 percent for accidents but a small decrease in fatalities. The trend for accidents has been upward each year of DAN's reporting. The average number of fatalities per year has been fairly constant over the last decade (See Figure Three). As mentioned above, most of the apparent increase in accidents is from more efficient reporting. Other reasons for an increasing number of accidents may be an increase in total exposure and changes in the profile of divers such as aging, new equipment developments, and other as-yet-unrecognized factors.

The decrease in the annual fatality rate for the last decade is probably due to better training in recognizing and treating decompression illnesses. Hyperbolic (decompression) chambers and emergency personnel to render first aid, evacuation, and treatment are available to most popular dive sites. This is particularly true in Florida and California. These two states have the most popular diving sites in the United States. Consequently, they account for almost one-half of the diving accidents and fatalities reported each year.

To fully appreciate any discussion of these statistics and data from DAN, it is necessary to have some knowledge of the sport of scuba diving.

Becoming a diver

The certification process is the only time a diver must pass anything like a fitness test or obtain medical clearance to dive. Most of the certifying agencies such as the Professional Association of Diving Instructors (PADI), National Association of Underwater Instructors (NAUI), and the Young Men's Christian Association (YMCA) require a good health statement that the student is fit to dive. The procedure varies. If a student claims good health, however, a physician's statement may not be required.

Most general care givers have little knowledge of conditions that might disqualify an individual from diving. Some physicians suggest that asthma, heart disease, insulin-dependent diabetes mellitus, or epilepsy disqualify their patients from diving. Others might caution their patients with these conditions but sign the certificates at request.

PADI's medical statement is accompanied by some guidelines for physicians to consider in their decision as to whether or not

their patients are physically and mentally fit to dive. These guidelines give some relative and absolute contraindications for diving (See Appendix A). Not surprisingly, heart disease, diabetes, asthma, and epilepsy figure prominently in the recommendations. Pregnancy is one of the absolute contraindications for diving. There is clear evidence that the fetus can suffer decompression sickness even if the mother does not. Most of the data have been obtained from animal experiments; nonetheless, it is evidence convincing enough that physicians should discuss this contraindication with childbearing-age women very carefully.

Popular medical literature seldom has guidelines for physicians on examining and counseling divers and potential divers.^{7,8} Most articles simply repeat the PADI guidelines. There has been more written about asthma as a contraindication for diving than any other disease.^{9,10,11} A review of the literature shows most specialists agreeing that asthma and diving are not compatible. Self-reporting by a group of divers suggests about one percent of divers have some degree of asthma. If asthma is present in five percent of the population, there is some avoidance of scuba diving as a recreational pastime by asthmatics.

Asthma

A review of diving fatalities and reports surveying asthmatic divers show very few fatalities are attributed to asthma. Particularly, very few fatalities in asthmatics are due to unexpected air embolism, which, in theory, should be of particular risk to the diver with airway obstruction. This has led the British Sub-Aqua Club to recommend that well-controlled asthmatics who have not wheezed in the previous 48 hours should be safe to dive.¹² Pulmonary specialists recommend careful evaluation of pulmonary functions and what triggers bronchospasm. Those with minimal bronchospasm and well-controlled asthma (inactive) should be carefully educated about the risk of barotrauma before they are cleared to dive.

Epilepsy

Epilepsy is given as an absolute contraindication to diving. In the last three years, DAN has reported two fatalities in divers with known epilepsy. Investigation revealed that one of the divers had stopped his medications three days before his fatal accident. He was not directly observed seizing, but his death was otherwise unexplained. One journal read by primary care givers had an article listing drugs that were not safe for divers.¹³ Anti-epileptics were on the list. Obviously, abruptly stopping such critical medications would be riskier than diving with the medication. The second death was incompletely documented, but the diver's sudden loss of consciousness before sinking could have been due to his seizure disorder.

Insulin-dependent diabetes mellitus

Insulin-dependent diabetes mellitus (IDDM) is suggested as being another absolute contraindication to diving. The deaths that involve both major types of diabetes tend to be related more to

cardiovascular complications than directly to diabetes or its treatment. In the last few years, there has been only one scuba-related death due directly to IDDM. A young student apparently fell unobserved into the swimming pool where scuba lessons were being held. It is likely that a severe hypoglycemic episode led to his drowning.

Physical tests

There is no yearly physical required and no way to lose one's certification for health problems. The choice of diving with infirmities acquired after certification is the diver's. (This is universally true; however, several years ago, I applied to the Cousteau group to dive with them in the Caribbean. They required a complete physical that included a cardiac stress test.)

The first day of scuba lessons includes a swimming test. Most certifying agencies use a standardized test that involves swimming 200 yards, floating, and treading water. The YMCA's test is more difficult. The test is strenuous enough that to pass it, most scuba candidates are reasonably fit. That is the last time most divers are required to demonstrate their being capable of the effort safe diving requires. I have dived with shops that required divers to pass ability tests before allowing them to dive from the shops' boats. This usually meant demonstrating some basic scuba skills and knowledge but was not truly rigorous.

The usual practice for most dive shops and diving charters is to ask for a certifying card. In addition, some vendors want to look at a diver's logbook to get an idea of the experience a diver has had and how long it has been since the last dive. Most dive operators think that the log gives a good idea of what kind of surface conditions, current and depth to which they want to expose their customers. Profit demands that shop owners serve as many divers as they can, so whatever procedure a shop uses is going to favor satisfying the customer. Divers doing shore entries and diving from private boats do not have to justify their ability and qualifications to anyone.

There are many levels of skills that a diver can attain. Most divers stop at "basic/ open water" or "advanced/ open water" certification, which enables them to dive just about anywhere and to get their air tanks filled at reputable shops. Most diving operations will take basic divers to sites that can include shallow wrecks, although there is a certification for wreck diving. Other levels of diving proficiency include cave diving, ice diving, and dive master. All of these proficiency levels still fall under the category of recreational/sport diving. The classic definition of recreational diving is diving that is accomplished while breathing compressed air and does not require decompression at the end of the dive.

Some recreational diving is further classified as technical diving. Technical diving includes dives in which the diver has overhead obstructions blocking his exit from the dive site; examples of this are cave, ice, and wreck diving. Other types of technical diving include those dives that are so deep that the diver must use special gas mixtures to avoid nitrogen narcosis or oxygen

toxicity. This type of technical diving is not recreational diving even though much of the equipment is the same as worn by the sports diver. Technical diving requires extra training and has extra risks as compared to pure sports diving.

Portrait of a diver and diving equipment

Diving requires a tank of compressed air, a regulator to deliver the air to the diver, mask, and fins. Safe diving adds a buoyancy compensator, a pressure gauge to tell the diver how much air is left in the tank, a depth gauge, a watch, and usually some extra weight to adjust the diver's buoyancy.

If a diver is diving in water that is cooler than 80+ degrees, he or she usually wears some kind of diving suit. The suit can be of varying degrees of thickness and flexibility; the basic rule being that the colder the water, the thicker the garment (and the greater the restriction of a diver's mobility). Dive garments are usually made of neoprene, which has a great deal of air trapped in the material. This means that the thicker the material, the more weight a diver must carry to correct the increased buoyancy of the wet suit. An adult male wearing a full-thickness wet suit will wear 20 to 30 pounds of weights around his waist to allow him the negative buoyancy sufficient to reach depth. If the diver has a great deal of natural buoyancy due to extra adipose tissue, even more weights are needed. How comfortable, enjoyable, and safe a dive is depends on good buoyancy control, and good buoyancy control depends on proper weighing.

As we review diving accidents and fatalities, the importance of weights and buoyancy control becomes apparent. Even overweighted divers can be agile and in control at depth; but on the surface they may be struggling to remain afloat and may be extremely awkward trying to board a boat or exit in a rolling surf. The effort required to counteract extra weight can increase panic in difficult situations. More weights increase pulmonary and cardiovascular work. Furthermore, if obesity correlates with lack of fitness, the strain on cardiac and pulmonary reserves becomes even more significant. If a critical situation develops at the end of a dive, fatigue is at its maximum. Poor fitness, lots of extra weights, and fatigue all work together to increase the danger in whatever situation divers find themselves. The 16 percent of fatalities that occur on the surface post-dive often reflect the factors of poor fitness, fatigue, and improper buoyancy control (extra weights) (See Figure Four).

Equipment problems or failure can be involved in diving injuries. The three items most frequently implicated are regulators, buoyancy compensators, and dive computers. Regulators step down the high-pressure air in the tank and, via a mouthpiece, deliver it to the diver with each inhalation. The mouthpiece has a flange and bitewing so that taking it out of a diver's mouth requires active effort. Most divers understand the life or death necessity of having a well-working regulator, and manufacturers frequently have routine maintenance requirements for their guarantees to remain valid. Nonetheless, some accidents are

Figure 4.

**Where Problems Occurred
that led to a Fatal Accident
(adapted from DAN 1993)**

1993 Percent 1992 Percent

At Depth	32.6	22.9
During Ascent	22.8	22.9
Surface-Post Dive	16.3	17.7
Unobserved	12.0	15.6
Surface-Pre Dive	6.5	5.2
Descent	5.4	11.5
Unknown	4.3	4.2

caused or worsened by poorly functioning regulators. Even a well-working regulator has a maximum number of respirations per minute (around 35) it can deliver effectively. Panicked, hyperventilating divers can exceed their regulator's capacity to deliver a satisfying volume of air. Distressed, air-hungry divers can pull their regulators out of their mouths while still submerged. These divers actually drown with air left in their tanks.

Buoyancy compensators (BCs) help maintain a diver's depth control. BCs have many different forms from collars to vests, with some of the more elaborate compensators incorporating the tank and weights. Inside the BC is an air bladder. The diver adds to or releases from the BC a volume of air that allows the diver to remain at a certain depth or afloat on the surface. The majority of BCs have a connection to the tank for automatic inflation, but more rudimentary (older) BCs require divers to take their regulators out of their mouths and blow through a hose to inflate their BCs.

BCs can cause the diver problems in two ways: by malfunctioning valves, hoses, and connectors or by inadequate lift for the diver's weight. The various valves in a BC need routine maintenance to ensure they are working properly. The didactic portion of scuba instruction emphasizes BC maintenance, but many divers do not use the same care for their BCs as they do for their regulators.

The BC should be matched to the diver's size and weight. Dive equipment shops usually match divers to their BCs with attention to the equipment's buoyancy limits. This same care may not be used when divers borrow or rent their equipment. A malfunctioning BC or a BC without the adequate capacity to keep a diver's face out of the water while on the surface can result in a diver's drowning.

Diving computers chart the dive profile by sensing both time and depth. Diving by the tables means that the deepest point of the dive determines the no-decompression time limits for the

dive. Dive computers constantly recalculate no-decompression time as divers ascend to shallower depths because they are ridding themselves of some of the nitrogen accumulated from the deeper portions of the dive. These calculations "give back" some dive time on most dives. Many divers consider the expense well worth the extra dive time they think they get from using a computer. The computers range from \$400 to \$750. Because the start-up gear for a new diver is expensive, not all divers can afford a computer.

If up to one-third of divers are using computers, it is significant that a little more than one-half of the accident victims were diving with computers. Does this mean the computers are not well-calibrated or that those using the computers get complacent about watching their air supply and other diving conditions? There is no clear answer. The good news is that decompression sickness suffered by computer users is more frequently a minor form as compared to that suffered by table users.

The additional gadgets with which divers can encumber themselves are truly amazing. Add-on equipment can include anything from underwater books to whistles. However, only two other pieces of equipment – cameras and spearguns – deserve mention, even though their malfunctioning is not the cause of accidents.

Diving with a camera

Approximately two percent of accidents and fatalities are associated with the diver doing photography, although many dive with a camera.¹⁴ There are important risks associated with using a camera. First of all, most divers intent on taking pictures are not very careful about watching out for their buddies. Buddies often get separated when one or both have their attention focused through a lens. In fatal accidents, it is common for the buddy to have "lost" the victim.

Secondly, many divers add extra weight when they are taking photographs so they will not be pushed around by currents. The hazards of weights are discussed above. Lastly, cameras are a distraction from the business at hand. Safe divers should be constantly checking their air supply, depth, time, and location. The statistics on diving accidents do not always mention whether a camera was involved or not. There especially are no statistics available on whether the victim's buddy was using a camera.

Undersea fishing

Undersea fishing is one of the reasons for diving. Other than sightseeing (53 percent), spearfishing is the second most common activity (eight to 13 percent) involved in diving fatalities. Contrary to popular opinion, dozens of hungry sharks do not immediately appear to gobble up both the catch and the diver. The use of the speargun in and of itself is not the risk; it can, however, distract divers from watching their buddies, depth, time, and air supply. A rare death was precipitated by a speared fish diving to depths, with the diver being pulled along.

Unique cause of death from breathing compressed air (gases)

There are two types of decompression illness (DCI) unique to breathing compressed air at depth:

Decompression sickness (DCS), or "the bends," results from breathing compressed air too long at too great a depth. Without proper decompression, prolonged deep diving results in air bubbles forming in tissues and the vascular system as the diver resurfaces. The symptoms can be minor, such as tingling in the skin ("niggles," as the British call them) or severe, with central nervous system symptoms or death. DCS remains the major cause of reported accidents.

The availability of hyperbolic chambers throughout the world and the improved training of divers, emergency response teams, and the medical profession have made death due to DCS rare. Only three DCS deaths were reported in the last three years.

Arterial gas embolism (AGE) occurs when divers ascend holding their breath. As the ambient pressure decreases, the pres-

sure in the lungs increases, rupturing alveoli and allowing air to escape into tissues and the circulatory system. Breathing compressed air and ascending as little as four or six feet while breath holding can cause AGE. This type of accident can happen when exiting a dive in rolling surf.

The more common sequence of events is panicked divers rapidly ascending while holding their breath. Even divers who have run out of air at depth will have overinflated lungs on the surface if they do not remember to continually exhale as they ascend. Each 33 feet of water represents one atmosphere of pressure. Divers at 33 feet have double the atmospheric pressure compressing the gas in their lungs. Rising to the surface from that shallow depth can double the gas volume in their lungs if they do not exhale. AGE represents the second most frequent cause of death in divers. Drowning is the most common direct cause of death.

Like DCS, the main treatment for AGE is hyperbolic pressure. The diver is placed in a chamber, recompressed and then decompressed on a prescribed schedule. From a morbidity standpoint, 63 percent of DCI cases clear completely with initial treatment.¹⁵ Of those with some residual, symptoms continue to resolve over the next two years until fewer than 20 percent report any residual.^{16,17}

Why divers die or are injured

The researchers at DAN have grouped the causes of diving fatalities under the following categories: inadequate training/experience, equipment problems, environmental causes, and host factors.

Inadequate training/experience:

There is no doubt that experience makes better divers. With experience, all of the little things and big things that can go wrong have happened to a diver at least once. When things go awry, an experienced diver more likely takes corrective action without panic; it is panic that kills. Very few scuba deaths are inevitable or not preventable. Reviewing accidents and fatalities reveals that at least one-half occur in divers with fewer than two years' or 60 dives' experience.

Sadly, many occur during training. Divers with extensive open water experience may try to do a technical dive, such as cave or ice diving, and find themselves once again novices and once again subject to all the hazards inexperience can bring. Therefore, we can consider some level of inexperience as excess risk.

Table 1

DAN Statistics on Accidents and Fatalities for 1991-1993

Year	Accidents			Fatalities		
	1991	1992	1993	1991	1992	1993
Total #	820	876	958	67	96	92
# Analyzed	437	465	508	63	80	87
% < 40 yrs.	74	73	71	48	55	47
% > 50 yrs.	5	6	10	19	14	31
Experience						
% < 60 dives	50	48	52	52	50	55
% with known medical problems	16	18	12	16	-	-
Medical Diagnosis						
DX (%) OF C-V diseases (known)	2 (.5)	7 (2)	4 (.8)	4 (6)	-	-
DX (%) OF C-V diseases post death				20 (31)	11 (14)	27(31)
Mental/nervous	8 (2)	10 (2)	4 (.8)	3 (4)	-	2 (2)
Asthma	5 (1)	8 (2)	5 (.9)	2 (3)	2 (2)	-
Other pulmonary problems	16 (4)	7 (2)	7 (1)	2 (3)	3 (3)	0
Obesity Generally over 90 percent said they were fit				5 (8)	3 (4)	7 (8)
Alcohol/drug*	-	-	-	7 (11)	7 (9)	1 (1)
Diabetes**	-	-	-	2 (3)	2 (2)	3 (3)
Cause of Event						
DCS	670	782	860	0	2	1
AGE	87	76	88	9	16	8
Drowning	-	-	-	36	55	57

Those divers with fewer than two years' or 60 dives' experience are a recognizable at-risk group.

Equipment problems: Divers need reliable working equipment suited to the type of diving they are doing. An experienced diver may appreciate this axiom and be a safer diver, but there is no way to underwrite excess risk secondary to equipment problems.

Environmental causes: Factors such as current, visibility, surface conditions, and overhead barriers figure prominently as the triggering factors for fatal accidents. Many of these conditions are handled well by experienced, fit divers. For others, these same conditions lead to panic and actions that lead to death, not safety.

Some diving situations are recognized as having extra risk. Cave and ice diving are added risk because the diver's direct exit from the underwater environment is blocked. If divers have significant equipment or physical problems in a cave, wreck, or under ice, they may not be able to reach safety no matter how experienced or capable they are.

Shore entry represents extra risk (See Figure Five). The surf requires effort to enter and exit, and visibility is often poor in the churning waters. Inexperienced divers who indicate that their diving locations include ocean beaches are divers at extra risk.

Other environmental factors that can lead to fatalities are things that can entangle or trap a diver. Kelp and fishing lines are examples of underwater hazards for divers. This type of factor is not predictable to either a diver or an underwriter.

Questions on how deep a diver goes are on most diving questionnaires. It is the question with only a limited prediction of excessive risk. The difference between 60 feet and 100 feet is a little more than one atmosphere of pressure. This demands more cardiopulmonary work and, therefore, demands better conditioning. Also, there is 40 more feet of water to ascend through in an emergency. But as long as a diver is staying within recreational (sports) diving limits – using only compressed air and not going beyond no-decompression limits – depth itself is not excessive extra risk.

Depth is a greater risk when people are “breaking the rules,” “going for their personal best,” or “pushing the limits” of recreational diving. At 100 feet the safe bottom time is only 20 minutes. This means most divers have not used all of their allowable air supply, have only just begun to explore the site and are really tempted to take the risk of staying beyond their safe time limits. These kinds of risk taking are not predictable from a diving questionnaire.

In practice, the best way to underwrite the risks from the environment or equipment is to look for surrogate factors that give an indication of just how much of a risk taker the diving applicant is. For example:

Figure 5

Dive Platform for Fatal Injuries

<i>Entry site</i>	<i>1993 Percent</i>
Shore	44.6
Charter boat	32.6
Private boat	20.7
Pool	1.1

- Does the applicant's driving record show evidence of recklessness or driving while intoxicated?
- Does the applicant list multiple hazardous sports?
- Does the applicant's medical history reveal a history of multiple injuries and accidents or hints of alcohol or drug use?

The answers to these questions give us a picture of an applicant's level of responsible behavior. The profile of a risk taker is developed from medical records, motor vehicle reports, and perhaps, liver enzymes. The most important things we learn from the diving questionnaire are the details of sports divers' experience and training and their participation in the more dangerous types of technical diving.

- Approximately 50 percent of accidents had some alcohol the night before diving. Deaths represent blood analysis for alcohol or drugs.
- Only one fatality was due to the diabetes, rest served as a risk factor for heart disease.

Host factors: Here are the characteristics that can be underwritten. We have discussed the problems of fitness, obesity, and asthma. There are other factors that deserve attention (See Table 1). An analysis of accidents and fatalities shows some of the characteristics that identify extra risk. It is important to emphasize once again that the denominator and true numerator are not known.

For instance, the percentage of accidents involving divers less than 40 years of age is 71 to 74 percent. This is probably significant but just how significant is not known without knowing what percentage of all divers are less than 40 years of age. The expense of diving and the large number of divers trained during the 1980s would suggest that the very young do not represent 71 to 74 percent of all divers. Yet, the young are more likely to have accidents. They seem to be the ones who are more likely to push the rules for speed limits, so it is not surprising to find them pushing the rules for safe diving.

In contrast to the accident statistics, divers younger than 40 years old represent only one-half of the fatalities. Divers aged 50 years and older have an increasing fatality rate. It is fair to say that host

factors other than being young and foolish exist in the fatality figures. The most important factor is cardiovascular disease.

In the last few years up to 31 percent of the fatalities have had heart disease as a cause or a significant contributor to the cause of fatal diving accidents. The same recognized risk factors for coronary artery disease (CAD) exist in divers. The stressors of exercise, emotion, and cold are all present to increase the possibility of CAD symptoms manifesting themselves during a dive. If symptoms of CAD present themselves at depth, the risk to the victim is increased by his environment. It is reasonable to have actions for scuba divers similar to those for aviators. The extra risk of a hostile environment plus disease seems identical. The major difference is that aviators have to have regular physicals and may have their flying privileges revoked if they are found to be in bad health.

Other types of cardiovascular disease that are represented in scuba fatalities are valvular heart disease, cardiomyopathy, history of arrhythmias, patent foramen ovale, and dissecting aortic aneurysm.

Of the other chronic diseases that represent risk to the diver's safety, pulmonary diseases other than asthma have presented as a risk equal to that of asthma. A history of such pulmonary problems as chronic obstructive pulmonary disease, chest trauma, known bleb formation, and heavy tobacco use must be considered with the same care as a history of asthma. New Zealand diving fatalities also suggested that pulmonary problems represented as much risk as asthma to divers.¹⁸

Mental/nervous disorders have little clear association with accidents or fatalities when the incidence of such disorders in the general population is considered. An important factor in diving accidents and fatalities is panic. As previously mentioned, panic is a killer. Panic seems more related to inexperience than previously diagnosed mental/nervous disorders.

Alcohol and drugs are present in only a few of the fatalities. Even so, the use of mind-altering drugs while diving can only

increase the risk from the sport. Again, it is reasonable for underwriters to use the same guidelines for underwriting alcohol- and drug-using scuba divers as alcohol- and drug-using pilots.

A word on sharks

It seems that sharks worry non-scuba-diving underwriters to death, but deaths due to shark attacks are rare in scuba divers. In the last three years, only one fatality was probably due to a shark attack. Bee stings account for more deaths each year than do these denizens of the deep. Talk to divers more than a few minutes, and you will discover that shark encounters are among their favorite experiences.

Summary

The host factors that represent the most risk for scuba-diving safety are poor fitness, overweight, chronic diseases, structural abnormalities of the heart and lungs, and multiple risk factors for CAD. Any of these factors, plus inexperience, a history of irresponsible behavior, or participation in technical diving should alert medical underwriting that a scuba diver has excess risk for fatal accidents.

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**APPENDIX A
PADI'S CONTRAINDICATIONS FOR DIVING**

Absolute Contraindications

Intracardiac shunts
Asymmetric septal hypertrophy
Valvular stenosis

Exercise induced asthma (EIA)
COPD with abn. PFT's
Restrictive pulmonary disease with exercise impairment
Hx spontaneous pneumothorax

Hx of seizures
Intracranial tumors or aneurysm
Hx of TIA or CVA
Hx of spinal cord injury, disease or surgery
with residual sequelae
Hx of CNS decompression sickness with residual

Monomeric TM
Open TM perforation
Tube myringotomy
Hx of stapedectomy
Hx of ossicular chain surgery
Hx of inner ear surgery
Hx of round window rupture
Facial nerve paralysis secondary to barotrauma
Inner ear disease other than presbycusis
Uncorrected upper airway obstruction
Laryngectomy or status post partial
Laryngectomy
Tracheostomy
Uncorrected laryngocele
Hx of vestibular decompression sickness

High grade gastric outlet obstruction

Chronic or recurrent small bowel obstruction

Relative Contraindications

Hx of CABG or PCTA
Hx of myocardial infarction
Hypertension
Dysrhythmias requiring Rx
Valvular regurgitation
Asymptomatic MVP
Pacemakers

Hx of Asthma, EIA, cold induced asthma
Hx of solid, cystic or cavitory lesion
Hx of secondary pneumothorax

Restrictive pulmonary disease without
exercise impairment

Severe migraines
Hx of head injury with sequelae
Herniated nucleus pulposus
Peripheral neuropathy
Trigeminal neuralgia
Hx of spinal cord injury
Hx of cerebral gas embolism Cerebral palsy

Recurrent otitis externa
Obstruction of external auditory canal
Hx of cold injury to pinna
Eustachian tube dysfunction
Recurrent otitis media or sinusitis
Hx of TM perforation
Hx of tympanoplasty
Hx of mastoidectomy
Significant hearing loss
Facial nerve paralysis
Full prosthodontia devices
Hx of mid-face fracture
Unhealed oral surgery sites
Hx of head and/or neck radiation

Hx of TMJ dysfunction

Peptic ulcer disease

Inflammatory bowel disease

Malabsorption states

Functional bowel disorders

Enterocutaneous fistulae that do not drain freely	Post gastrectomy dumping syndrome
Esophageal diverticulum	Periesophageal or hiatal hernia
Severe gastroesophageal reflux	
Achalasia	
Uncorrected hernias of the abdominal wall potentially containing bowel	

Insulin dependent diabetes mellitus	Obesity
Non-insulin dependent diabetes mellitus	Renal insufficiency
	Hormone excess or deficiency

Pregnancy

Sickle cell disease	Sickle cell trait
Polycythemia	Acute anemia
Leukemia	

	Chronic back pain
	Amputation
	Scoliosis that impacts PFT's

	Aseptic necrosis
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Inappropriate motivation to dive (to please spouse) despite personal fears	
Claustrophobia and agoraphobia	
Active psychosis	
While taking psychotropic medications	
Hx of panic disorder	
Drug or alcohol abuse	
