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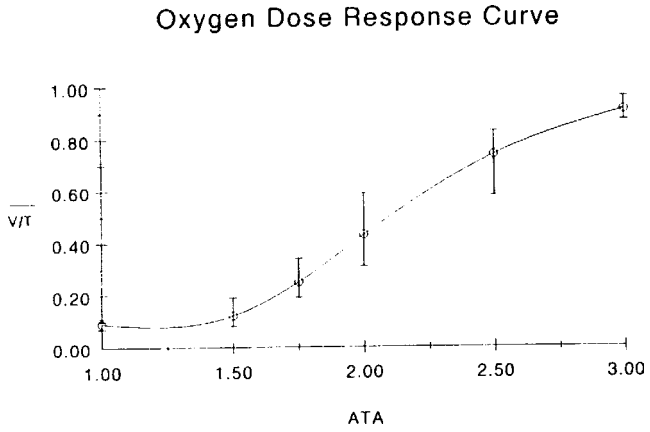

which borders on acute oxygen toxicity. The curve of V/T versus ATA shows a minimal and only gradual increase to 2.0 ATA. At 2.5 ATA, a sharp increase in angiogenesis is noted ($p<0.001$ ANOVA). This study strongly implies a greatly reduced response at treatment depth of 2.0 ATA as compared to 2.5 ATA and to 3.0 ATA.

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ARTICLES OF INTEREST REPRINTED FROM OTHER JOURNALS

WHY US DIVERS DIED IN 1991

Ben Davidson

The National Underwater Accident Data Centre (NUADC) at the University of Rhode Island has been recording diving fatalities involving US citizens for 20 years. To further your awareness of the causes of death so that you may dive more safely, *Undercurrent* has been reporting their analysis for 15 years. The 1991 report on scuba fatalities is the second joint effort between DAN and NUADC.

In 1991, 67 recreational scuba fatalities were reported. While 67 is the second lowest number of scuba deaths recorded since 1970, at least 90 scuba related deaths have been reported for 1992. Of the 67 deaths in 1991, the youngest was 16 years of age and the oldest was 72. Twenty-one percent of all fatalities were 50 years of age or older. The female deaths were 25 percent of the total.

In determining the overall fatality rate, it is difficult to obtain the exact number of active divers. The number of newly certified divers is not available and not all divers remain active after their first year of diving, while some drop out and then re-enter. Nonetheless, NUADC estimates the active diver population at 2.5 to 3.2 million divers at the end of 1991, leading to a fatality rate of 2.09 to 2.68 per 100,000 participants.

(Undercurrent Editor's note:
The National Sporting Goods Association surveys 20,000 households annually to determine participation in recreational sports; they estimate 2,000,000 divers.)

Location of Diving Fatalities

Florida recorded 14 scuba fatalities in 1991, down from 22 in 1990. There were 10 scuba fatalities in California in 1991, while 14 were noted in 1990. Pennsylvania had four deaths in 1991, two occurring in the same quarry, several months apart. New Jersey had four wreck-diving deaths, Hawaii three fatalities, while two were recorded in Texas. One of these victims died of hypothermia after 20 hours in the water without a wet-suit, while his wet-suited partner survived. They had been diving offshore, but drifted away from their boat in the current. They reached a buoy after several hours in the water and clung to it overnight. The decedent died shortly before rescue.

Five Americans died in Cozumel, Mexico. The Bahamas accounted for three fatalities, and one death each was reported in Okinawa, Palau, Dominica, Bonaire and St. Maarten.

Dive Activity and Certification Status

Of the 67 scuba fatalities, 59 divers were certified to dive (five of whom were taking advanced level classes), while four were undertaking their initial training. Four divers were without proper certification or supervision.

The percentage of charter boat fatalities was 30.2% in 1991 and of shore-based fatalities was 46%.

Nine persons conducting technical level dives were killed. As stated in Technical Diver, "technical diving is a discipline that utilises special equipment and methods to improve underwater safety and performance, enabling divers to extend their range beyond the established recreational

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envelope." These include cave dives, wreck penetrations, ice dives, and deep, extensive decompression dives.

Technical divers have invested significant amounts of time and money to safely accomplish dives. Seven of these nine fatalities did not have the proper training or experience for technical level diving.

Cave deaths

Three double fatalities in caves accounted for six of the seven cave deaths.

For example, a 30 year old female and a 32 year old male entered a cave system despite park regulations and warnings from their instructor. The male had several specialty certifications while the female was making her first dive since certification. After conditions became silty, only the third member of the team could find the way out. They did not use guide lines. When recovered, both victims were out of air.

A husband and wife buddy team died while attempting a cave dive in Missouri. The husband was reported to be an experienced diver, having "logged over 600 dives", while his wife was new to diving. Neither diver was trained in cave diving. They entered the system with no guide lines to the surface. The husband carried the main light and the wife carried the backup light. Reportedly visibility is generally about 9 to 12 m (30 to 40 ft), but recent rains and flash floods had dropped the visibility to less than 1.5 m (five ft). Although this cave system is not complicated, it took the recovery team over one day to find the bodies which were located more than 90 m (300 ft) into the system and about 3 m (10 ft) off the permanent line. The husband's inflator hose was disconnected. When tested, it caused the buoyancy compensator to continually inflate.

[Undercurrent Editor's Note: We published a story in the February 1993 issue of Undercurrent entitled The Extra Weights We Carry- The psychology of dependency." These two cases are strikingly similar to the situation described in our story, where an experienced male led an inexperienced and dependent female. Our subject was lucky to survive. These four people didn't.] *See page 98-100 of this issue.*

Finally, the experienced cave diver who died was trapped in a cave following a geologic disturbance that blocked the cave exit.

Environment

While accidents and fatalities are usually the result of multiple factors, in most instances, there is generally one event or condition that precipitates a sequence of events. In three of the 1991 cases, the environment was the probable starting event. All occurred at the surface, after successful completion of an uneventful dive.

Panic was the probable starting cause in one training fatality, and narcosis was the probable starting cause in an advanced training fatality.

In the narcosis case, the victim was a 22-year-old female making a deep dive for her advanced open water certification at 30 m (100 ft). She was missing at the 4.5 m (15 ft) stop and was recovered by the two dive instructors. She had 110 bar (1,600 psi) remaining and her 10 kg (22 lb) weight belt was in place. She was recompressed, but died from drowning.

Entrapment was the initial cause in one case. The victim was an experienced cave diver who was trapped in a cave following geologic disturbance which blocked the cave exit. One member of the team found the exit and survived.

Heavy Seas

In some cases, heavy seas contributed to the drowning. A male who was diving with his buddy in the tropics experienced difficulty while surface swimming to the boat. The buddy managed to reach the boat, but the victim did not and drowned. The victim surfaced, called for assistance, then submerged. When recovered, the tank contained sea water and the victim was still wearing his weight belt. Fellow divers reported the sea state was "rough as hell".

A 3l year old female receiving instruction in open water certification and surf entry had made one previous similar dive and had experienced an episode of hyperventilation in the pool. She and the instructor swam under the surf, surfaced, and switched from regulators to snorkels. A large wave caught the victim and she aspirated sea water. She was rescued with difficulty by the instructor who initiated CPR, but she still drowned.

Equipment Unfamiliarity

Equipment unfamiliarity may have precipitated the drowning death of a 30-year-old-female who had been certified about five years. She was diving from a private vessel in about 13.5 m (45 ft). She and her buddy began their ascent together. She had 41 bar (600 psi) in her tank. During the ascent, she signalled to her buddy that she needed to share air, which they did for a brief time. Her cylinder was equipped with a J-valve which the diver must operate to obtain the last 20 bar (300 psi) of air. The buddy noted that the J-valve was up and attempted to pull it down.

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However, she started struggling and pushed him away, then made a breath-hold ascent. She reached the surface, then sank.

Drowning death often follows the occurrence of factors which prevent the diver from reaching or remaining at the surface. Buoyancy control not only makes diving pleasurable, but also is a self-rescue skill which should prevent drowning.

The inexperienced diver has probably not learned the technique well enough so that the responses are automatic. In a stressful situation, such as out-of-air and negative buoyancy, the diver responds inappropriately. As the BC inflation and deflation controls are operated by the left hand in most designs, the stressed diver has only a 50/50 chance that the proper control will be activated when attempting to control buoyancy in an emergency. Even experienced divers frequently make errors in pressing the proper button during routine dives.

An inexperienced diver who panics when attempting unsuccessfully to inflate a buoyancy compensator by depressing the deflate button will not make a decision to use the other button. Instead, in all likelihood, the diver will merely press the deflate button even harder. Several of the drowning deaths appeared to fit the pattern of an inability to control buoyancy even though the equipment was found to be working properly and there was sufficient air in the tank.

While doing a navigation exercise during the fourth open water check out dive, a 28 year old female unintentionally descended below the thermocline. Her buddy helped her ascend, but she started thrashing and struggling. Reportedly, she then used the deflator instead of the inflator to establish buoyancy. The buddy was unable to lend further assistance, so he surfaced and called for help. The body was located after a one hour search. The autopsy indicated the cause of death was drowning, caused by an air embolism.

Equipment Problems

Equipment difficulty may have played a role in the case of a 26 year old male who made a 39 m (130 ft) dive for a 25 minutes using “independents” (twin tanks without a manifold). He was reported to have done only a few dives with this equipment. Approximately 20 minutes after the dive began, he attempted to use his buddy’s regulator, but could not. He became unconscious at depth and was brought to the surface by fellow divers. On investigation, the equipment was in working order; however, one tank was empty and the other contained 234 bar (3,400 psi). The decedent was probably not breathing during rescue to the surface and, in effect, was ascending while breath holding.

A 46 year old male with 22 dives since certification was diving with companions on a wreck when he was discovered on the bottom with his free-flowing regulator out of his mouth. Companions attempted to inflate his BC, but the tank was apparently empty due to the free-flowing regulator. His pony bottle was full. The victim had complained about an “upset stomach” and a “tight weight belt” prior to the dive.

Failure to Drop Lead

In reviewing diver fatalities, it is amazing to find the number of divers in distress who fail to remove their weight belts. As one might expect, uncertified divers may fail to drop their weights, but even trained divers die without discarding their lead. Here are some of the cases:

A 43 year old male was making his third dive of the day and had just started the descent with his buddy after indicating “OK”. The buddy noticed his partner not descending and returned to the surface, to hear him say that he had an “emergency”. He then became unconscious. The buddy was unable to support the victim at the surface and the body sank. Rescuers found the body after a one and a half hour search. The victim wore all his weights (12 kg or 26 lb) strapped to the tank.

Another victim was a 30 year old male who had been lobster diving in an inlet and had made three long shallow dives to 6-9 m (20-30 ft) during the day. An observer witnessed him surface, call for help, then sink. The recovery team located the body 19 hours after the incident. There was no air in the tank or buoyancy compensator. He was wearing a 5.5 kg (12 lb) weight belt while clad in a bathing suit.

A 16 year old male with limited diving experience was making a 27 m (90 ft) wreck dive for an advanced level certification. After agreeing to ascend, the buddy team could not find the down line and initiated a free ascent. About 3 m (10 ft) off the bottom, the victim came to this buddy with the regulator out of his mouth. The buddy gave the victim his octopus and signalled to ascend. The victim did not respond, so the buddy ascended on his own and called for assistance. The body was located in about 5 minutes. The victim’s tank had 34 bar (500 psi) remaining and his weight belt was still on.

A 26 year old male uncertified diver had been diving with a certified buddy in a high altitude lake. He had had trouble equalising his ears on several previous dives. After descending and ascending several times, both divers were able to descend to approximately 4.5 m (15 ft). The victim signalled “OK” to his buddy who then turned away and swam a short distance. The certified buddy turned around and noticed his partner on the lake floor with his regulator out of the mouth and mask removed from the

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face. The victim was still wearing his 14.5 kg (32 lb) weight belt. The buddy brought the victim to the surface and called for help. The tank pressure was 138 bar (2,000 psi) when measured after the accident.

Two buddies did a shore entry to about 4.5 m (15 ft), while their friend sat on the beach and watched. The inexperienced member of the dive team left the water and lent his gear to his uncertified friend, unknown to the other buddy. The uncertified diver was observed to be in distress on the surface a short time later. The buddy who had lent the gear swam to the panicked victim and attempted to render assistance; however, the victim ditched all gear except his weight belt and sank to the ocean floor. The search team located the body in one hour. The tank was out of air. The cause of death was drowning.

A male untrained diver was using borrowed gear and collecting lobsters in the company of two certified lobster divers. He was diving alone and was observed to surface, call for help and then submerge. Witnesses went to his assistance immediately and found him out of his scuba gear on the bottom, but still wearing his 3 kg (7 lb) weight belt and one fin.

Stress and death

Some presumably healthy individuals die suddenly and unexpectedly. The victim is usually not rescued in time to allow resuscitation at a medical facility. The cause is nearly always cardiovascular disease.

The cardiovascular response to diving stems from different kinds of stress. Physical stress from exercise and cold results in increased oxygen consumption and increased work load for the cardiovascular system.

Emotional stress may result in an acute anxiety reaction causing a very rapid heart rate, elevated blood pressure and hyperventilation. These stresses may result in dysrhythmia, angina and sudden death in the presence of cardiovascular disease.

Anxiety can produce a rapid forceful heart rate of which the individual becomes acutely aware. This awareness can result in rapid breathing which, in turn, creates a reverberating circuit of increased, anxiety-associated heart rate and respiration rate. The panic or acute anxiety may cause high blood pressure and pulse rate of 170-180 per minute.

Normal breathing rate is around 15 breaths per minute. A person in panic, breathing rapidly, may achieve a rate of 35 breaths per minute. Dr Glen Egstrom at UCLA found that a diver at 18 m (60 ft), with breathing at 35 breaths per minute, will over-breathe the average regulator. The regulator simply cannot handle this exaggerated level of breathing requirement and will not provide needed air.

These stresses demand increased output from the heart and an increased blood flow. If disease is obstructing, blood flow becomes inadequate for the working heart. The result may be chest pain, lethal rhythm disturbances or heart failure.

Cardiovascular disease was a factor in half the deaths of divers older than 40. There were nine deaths immediately caused by myocardial infarction and an additional five deaths from drowning after myocardial infarction (heart attack). Four more victims had a cardiovascular disorder such as hypertension and coronary artery disease.

In the age 40 and under group, there were two deaths from drowning with cardiovascular disease as a contributing factor. Thus, at least 20 victims had cardiovascular disease severe enough to have disqualified them as divers.

A heart attack that happens to a tennis player or jogger does not place the individual in further jeopardy from the environment. However, a diver who develops a heart attack during a dive may drown. Divers with risk factors for coronary artery disease, age, smoking, hypertension and other life style characteristics, should have a careful examination to search for the disease.

A 51 year old experienced scuba diver and a member of an elite US military organization was hypertensive and a smoker. He had experienced difficulty on previous dives because of shortness of breath. He and a companion were diving in 1.6-3 m (5-10 ft) of water, where he died of cardiac arrest. The autopsy disclosed coronary atherosclerosis.

A 72 year old male diver had a history of emphysema and tobacco abuse. On entering the water, he immediately developed distress and shot to the surface. He was rescued and placed in the boat followed by CPR but died from a heart attack.

An obese 58 year old female (clearly not physically qualified for scuba diving) got into difficulties while diving in the tropics and died of a heart attack. A male with morbid obesity, hypertensive cardiovascular disease, and diabetes experienced cardiac arrest at the end of a dive.

A female who had made 150 dives had no known medical problems and had undergone a physical shortly before the dive trip. She developed difficulty on the first dive while at about 12 m (40 ft). She surfaced conscious and speaking, but developed cardiac arrest during rescue. Autopsy disclosed coronary artery disease.

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A male who had know coronary artery disease with two previous heart attacks and a three vessel coronary artery bypass graft procedure was making his first dive since surgery one year before. He surfaced, called for help and then developed cardiac arrest at the end of a relatively uneventful dive. The cause of death was determined to be acute myocardial infarction.

Fainting

A syncope is a sudden loss of consciousness, i.e. fainting. The most common cause is decreased cardiac output, often caused by arrhythmias and either slow or rapid heart rate (below 35 or 150-180). Other causes may be decreased return of blood to the heart through the veins, low blood volume, and obstruction to cardiac output. Fainting in apparently healthy people is common.

The simple faint is a form of syncope due to peripheral dilation of blood vessels as a result of many different stimuli. The person who faints due to apprehension about a needle stick or minor injury is familiar to all. Anxiety, which may range from mild to the panic attack, may produce syncope by hyperventilation, which causes low CO_2 content in blood, producing cerebral vasoconstriction and causing unconsciousness.

Exercise syncope may occur in the person with obstruction to cardiac output so that normal activity is tolerated, but there is insufficient response to the demand for cardiac output from the exercise. A sudden drop in blood pressure on assuming upright position occurs in individuals taking certain blood pressure medications as well as in a few apparently normal individuals taking no medication whatever. Seizures, hypoglycaemia (low blood sugar), anaphylactic reactions, nitrogen narcosis, oxygen toxicity, excessive carbon dioxide, contaminated breathing gas, and insufficient oxygen in the breathing gas may also cause fainting.

Several drownings occurred after the diver appeared to lose consciousness. The drowning itself was the probable cause of death in most cases. The diver with an interrupted air supply may lose consciousness during reflex breath-holding prior to inhaling water.

A 52 year old male was diving on and offshore wreck at 24 m (80 ft) with one buddy. The buddy pair surface down current from the boat and were unable to reach it. The surviving buddy was picked up by another boat, which then came across the diver who had dropped his tanks and weight belt and was floating on his back with his buoyancy compensator inflated. His heart had stopped. The combination of cold water, hypothermia and mild coronary artery disease with maximum physical effort in swimming against current seem to have been the cause.

A 40 year old experienced diver was trying out new scuba gear in a shallow restaurant pond, when he died. An employee of the restaurant observed the victim swimming underwater, stand up, remove and replace his mask and then resubmerge. Later the victim was found floating face up with his head underwater. The presence of coronary artery disease, along with the exertion of using scuba gear, suggests a cardiac event as the cause of death.

A male discontinued a dive and returned to surface where he denied difficulty, but was coughing. He stated that he would rest on the surface. A short time later he was floating face down in the water and, on rescue, was in cardiac arrest. Autopsy revealed acute myocardial infarction and coronary artery disease.

Contributing factors

While a high percentage of deaths can be attributed to drowning, it is important to understand the contributing cause (Table 1).

TABLE 1

Contributing factors	Number of divers
Insufficient air	19
Buoyancy problem	15
Entrapment	11
Cardiovascular	8
Alcohol/drugs	5
Panic state	5
Nitrogen narcosis	4
Air embolism	3
Hypothermia	1
Obesity	1
Rapid ascent	1
Total	**73**

The majority of the drowning cases were associated with running out of air. Many inexperienced divers simply ran out of air unexpectedly, and were unable to perform self-rescue.

About half the drowning deaths occurred during ascent or on the surface after the dive. In several cases, divers died while getting into trouble swimming on the surface back to the boat. In two cases, buddies got separated on the swim and the one who dropped behind got into trouble and drowned.

A female (diving from a charter boat) surfaced with her companion 140 m (150 yards) from the boat. On the swim back, she became separated from her buddy, who

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was in the lead and did not realise she was in difficulty. When found on the bottom, her tank was empty and she was still wearing her 16 pound weight belt.

A 38 year old male had not made a dive since certification one year before. He surfaced with his buddy after reaching 35 bar (500 psi), but failed to keep up with his buddy on the swim to the boat. Recovered from the bottom by the dive guide, he was resuscitated, but died about 48 hours later. His cylinder was empty, his buoyancy compensator not inflated.

Booze and drugs

Alcohol and drugs contributed to at least two deaths, while several other victims were found to have either or both in their system. When one of a three member buddy team developed difficulty, the other two escorted him to the surface. Shortly after the diver in trouble was rescued, another buddy was found floating face down in water with his regulator out. An autopsy found a substantial amount of cocaine in his system.

When an individual is excited, as the dead diver was when he was taking care of his buddy, his body naturally produces catecholamine, a neurotransmitter. The synergistic effect between catecholamine and the cocaine apparently affected his heart.

A male who was attempting to recover a sunken lobster boat was drinking beer before the dive and had a history of drug and alcohol abuse. He was wearing a 18 kg (40 lb) weight belt with a wet suit. Unknown difficulty developed at the surface and he sank. There was no standby diver and the body was recovered about two hours later.

A female on a three week diving trip to a tropical area had made many dives and was taking medications for depression. Reports also slate that she "drank heavily" during her stay. She made a dive with a guide to 36 m (120 ft) and then, apparently narked, she left the guide and went to 75 m (250 ft) where she began to take off her scuba gear. The guide forced her to the surface, where she died after 15 minutes.

Entanglement can also cause drowning. A 28 year old male was salvaging lost anchors near a dam site when his buddy experienced difficulty and surfaced. The recovery team located the victim suspended in 4.5 m (15 ft) of water by a rope caught on his leg. There were cut marks on the rope and his buoyancy compensator buckle had been unlatched.

Drowned with Air Remaining

Some drowning victims had air in their cylinders.

A 31 year old female was diving in a quarry with 7°C (46°F) water, limited visibility, and an unfamiliar dive buddy. They made an unplanned ascent due to cold and lost contact with each other. The victim did not surface and was found on the bottom some time later. One fin was missing and her buoyancy compensator was not inflated. When tested, the tank had 138 bar (2,000 psi) of air remaining.

A 41 year old male was participating in an advanced class of six students. At 36 m (120 ft) the instructor stopped the dive because of decreasing visibility and the party surfaced. The victim was missing and his body was located on the bottom 90 minutes later. His cylinder contained 34 bar (500 psi) and he was still wearing his 15 kg (33 lb) weight belt. This is the case of another drowning victim, who was overweighted and failed to drop his belt.

An 18 year old male was diving with a companion in a sink hole. On their second dive, the victim indicated a desire to ascend and the buddy team started for the surface. The victim did not appear at the surface. The buddy searched for a short time and then called for assistance. The dive recovery team found him on the bottom with the regulator out of his mouth. The inflator hose for the buoyancy compensator did not match the connector on the buoyancy compensator and, therefore, could not be connected. The cylinder contained 14 bar (200 psi) when turned off.

Diving Alone

In 1991, six deaths were solo diving fatalities. In one case, a 43 year old male was diving alone from a rocky shore in an area of strong current and rough surf using rental gear. A witness observed the victim in distress. Lifeguards were about half a mile away and, by the time they could be summoned and reached the scene, the victim was floating face down in the water. He had abandoned his gear and weight belt.

A 49 year old male surfacing after spearing a fish indicated to his friend on the boat that he needed assistance, then submerged. The friend dived in without any gear and unsuccessfully attempted to pull the diver up. A diver from another boat attempted to reach the victim, but was low on air. He saw the victim stop kicking and air bubbles discontinue from the regulator. At a thermocline at 24 m (80 ft), visibility dropped from 24 m (80 ft) to 1.5 m (5 ft). The victim had allegedly been drinking rum prior to the dive.

A 32 year old male, a graduate of a commercial diving school and an active instructor, disappeared while solo diving. He planned a dive to 90 m (300 ft), using multiple tank harnesses. His body was never located.

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Hit by a Boat

A 17 year old uncertified male was diving in about 9 m (30 ft) with three friends, none of whom towed a dive flag. When he surfaced he was hit by a boat and lacerated by the propeller. It may be that the victim surfaced because he could not control his buoyancy. The 160 cm (5'4"), 68 kg (10.5 stone or 150 lb) youth dived in his swim suit and was using an aluminium tank, which provided three to four pounds of positive buoyancy at the time of the accident.

Analysis of DAN's DCS accidents

The Divers Alert Network, DAN, received reports on 708 accidents involving American divers in 1991. The cases of 437 sport divers who were diagnosed as being bent had adequate data for analysis. 288 cases occurred in the U.S. Some interesting foreign data:

Mexico	35
Bahamas	29
Caymans	20
Honduras	11
Belize	7
Turks and Caicos	7
Bonaire	4

Here are a few pertinent aspects of those cases, which we hope will provide you with tips to help you dive more safely.

Injured Diver Characteristics

The 1991 age distribution is similar to previous years. One difference is six injuries of 10-14 year old divers, which were equal to the total for the previous four years combined. While Open Water Certification limits young divers to 18 m (60 ft), two were deeper. Three of these cases were DCS I, involving pain-only symptoms, the other three were DCS II, of which one case was possibly embolism. There were no residual symptoms in any of the divers.

Approximately 27% of the injured divers were female, about the same percentage as the general diving population. Forty-five percent of the female injuries occurred in the first two years of diving, compared to 21%t of the total male injuries.

Contrary to myth, DAN data suggest that women seem neither more nor less likely than men to experience decompression illness.

Diver Health and Fitness

Divers with current medical problems may be more susceptible to DCS than healthy divers. Twenty-six percent of all injured divers had a current medical problem. Fifty four percent had at least one previous illness. Chest-lung problem, GI and abdominal problems, spine and back problems, and muscular and skeletal problems were the most common previous illnesses. Thirteen percent had suffered a previous decompression illness.

What I find curious, is that 90% of the injured divers proclaimed themselves "fit." Having observed thousands of divers over the years, I do not find my fellow aquanauts to be unusually fit people. We are probably no better or worse than the general population. For example, it is not uncommon to have a number of people on a dive boat 14 kg (30 lb) or more overweight.

Do only the fit divers get bent? Sounds like the injured divers want to blame someone else other than themselves.

Seventy-two percent stated they exercised weekly, averaging 3.5 days a week per diver. Seems like the 28 % who don't exercise are lucky to stay fit.

Strenuous Exercise Before, During or After a Dive

Exercise to the point of muscle fatigue may contribute to decompression illness, and should be avoided from one to six hours before and after diving. Twenty-nine percent of the injured divers admitted to performing some form of strenuous activity prior to or after their dive.

Sixty-one percent of the divers who got bent recalled that their dive itself included strenuous activity. Divers who struggle in a current or make a long and tough swim would be well advised to take extra time on a decompression stop.

Alcohol Use, Nausea, Fatigue

While the exact role alcohol consumption plays in decompression illness is unknown, it apparently contributes to decompression illness because it tends to cause dehydration. Without appropriate rehydration, repetitive post-dive drinking for several days may lessen the body's ability to offgas nitrogen accumulated during scuba diving. Performance may be impaired for many hours after being intoxicated. Thirty-seven percent of the divers who got bent drank alcohol in the 12 hour period prior to their dive.

I have personally found that rules prohibiting the moderate intake of alcohol, a beer or a glass of wine, prior to diving more often than not represents a new form of moralism, rather than any effort to prevent bends. The DCS culprit seems to be dehydration, which is caused by any number of substances and is cured by drinking water or

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juices. The "one beer and you're finished diving for the day" rule has nothing to do with preventing bends. It is a rule imposed by charter managers and boat captains who get off on exercising moral authority. Let he who drinks a beer be required to drink two glasses of water. With that the problem is solved.

Getting smashed is another matter. For the past several years, nausea and diarrhoea have been the most common acute conditions affecting the diver on the dive day. Vomiting and diarrhoea may well contribute to diver dehydration: if the diver is hung over, he is already dehydrated. Furthermore, fatigue and lack of sleep can impede optimal physical performance and lead to inappropriate decision making. One-third of the 1991 injury population began the dive-injury day fatigued or with less than an adequate amount of sleep. That, too, can be another symptom of excessive partying.

Smoking

The percentage of current smokers in scuba diving continues to fall below the national average: 52% of the U.S. population are either current or past smokers: the injured diver population has ranged between 31% and 43%t current or past smokers. Twenty-eight percent of the national population currently smoke, while only 15% of the DAN injury population were current smokers.

The percentage of arterial gas embolism is higher among current smokers than the entire population, but the percentage of contributory factors was also higher. As a result, no conclusion can be made that smokers are at a higher risk for embolism than non-smokers, based on current data.

Characteristics of dives that resulted in DCS or AGE

Arterial gas embolism (AGE) can occur in any diver who ascends too rapidly from any depth. The typical AGE incident occurs within dive table limits and or during the first dive of the first day.

There has been a resurgence of inexperienced divers suffering from AGE, 52% in 1991 compared to 34% in 1990. Only 60% claim to have made a rapid ascent, the predominant cause of AGE. Time and depth exposures are not major contributing factors: only 46% of divers went deeper than 24 m (80 ft), and 60% were within the no-decompression limit of the tables. Decompression sickness (DCS) results from the duration of exposure at a depth of 9 m (30 ft) or greater. It was associated with dives 24 m (80 ft) or greater, repetitive diving within the tables and with multi-level profiles. A rapid ascent occurred in 59% of AGE cases but only 22% of DCS cases.

DCS I includes all cases of pain-only bends occurring in the extremities and also includes skin bends. DCS II is more serious, and includes all cases with neurological or cardiopulmonary symptoms except those diagnosed as air embolism. The percentage of DCS II appears to be rising annually.

The most common initial DCS symptom was pain, but up to six symptoms were reported by individuals. Numbness and pain appeared in more than 50%, corroborating the neurological nature of most decompression illness. Two symptoms reflect the serious nature of progressive neurological DCS: 13.5% had difficulty walking at some time after their dive, and six percent suffered paralysis.

Nearly 19% of those injured continued diving after the first symptoms of decompression illness. This is presumably due either to a lack of knowledge or an unwillingness to admit the possibility of decompression illness. About 2.5% had suffered a previous episode of decompression illness. The second bends hit tends to be more severe than the first.

Decompression illness in computer and table divers

Compared to table users, computer users can stay down longer, and make earlier repetitive and deeper dives. When making multi-level dives, computer users can go deeper during their repetitive dives.

The use of computers supposedly enables divers make repetitive dives more safely. However, while using computers, more than 80% of the divers suffering decompression illness in 1991 made multi-level, repetitive dives deeper than 24 m (80 ft). Other factors such as multi-day diving and fatigue appear less important.

The number of divers who suffered pain-only bends (DCS I) was approximately equal in both computer and table users as was neurological or more serious bends (DCS II). DCS II was much more common than DCS I in both computer and table divers. Slightly less than half the divers with decompression illness used computers in 1991.

Approximately 25% of computer divers thought that they were within the tables. However, only 15% reckoned they were diving outside the standard decompression table limits. Staged decompression has decreased in computer users, presumably as the computer indicates there is no need for decompression at the end of the dive schedule.

Arterial gas embolism was two to three times greater in frequency in table users than computer users. It may be that computer users are more experienced divers, who have been diving both more often and longer than table users.

Rubicon Research Repository (http://archive.rubicon-foundation.org)

This may indicate that table users were more likely to miscalculate time and run out of air.

Equipment Problems

Fifteen percent of the 1991 cases involved equipment problems, which not only includes failure or malfunction. but also includes unfamiliarity with the equipment. Problems mainly occurred with the regulator, dive computer or buoyancy control. Other problems included gauge or timer problems, an improper wet suit fit, a mask leak, a tank not turned on, and three cases where someone else's actions or equipment reportedly led to an injury.

First Contact for Assistance

Approximately half the injured divers called for assistance within 12 hours of the onset of their first symptom. Some divers delay seeking medical evaluation because they may not feel their symptoms are serious enough. Others may not recognise their symptoms as being related to decompression illness. Pain can easily be mistaken for the aches and pains associated with exertion. A remote dive site may limit access to medical evaluation. Delays in treatment may decrease the possibility of immediate and complete resolution of symptoms. Thirty six percent of all injured divers received no first aid.

Post Hyperbaric Treatment Residuals

After completion of hyperbaric therapy, 48% of the treated divers still had residual symptoms. Twenty four percent had a neurological residual and 24% had residual pain. At the three month follow up, 17% of injured divers still had some symptom of injury.

Decompression illness often leads to permanent injury. Hyperbaric therapy provided complete resolution of symptoms in a little over half of all cases. This percentage might be improved if more divers sought earlier treatment.

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MORE DIVES, MORE TROUBLE

Tim Parish

The 1994 diving season saw British divers basking in a relatively long hot summer, which undoubtedly contributed to the increase in the number of annual man-dives carried out to 2.5 million, compared with 1.75 million in 1993. This in turn has helped lead to an increase in reported incidents in 1994 over previous years, 149 in 1992 and 263 in 1993, with a total of 385 incidents logged into the BS-AC database for the 1994 statistical year (October 1993 to September 1994). Twelve divers died.

The elevated figures for 1994 should not, however, be interpreted simply as an indication that more incidents took place. As in 1993, a significant factor was a further increase in both the sources and the accuracy of the data to which the BS-AC has access. To give an idea of the current breadth of our database, last year we received 164 Incident Report Forms from BS-AC members, 192 incident reports from the Coastguard Agency, and 106 from the British Hyperbaric Association (BHA), whose data is supplied to us by The Institute of Naval Medicine. This was added to by 33 newspaper reports, 54 reports from the RNLI, and 40 directly from the Diving Diseases Research Centre. While we can never guarantee to collect information on 100 per cent of serious incidents, we are now probably as close to that goal as we can practically be.

The monthly pattern of incident occurrence changed in 1994. The usual peak seen around the Easter public holidays was significantly reduced, particularly for decompression incidents. This was undoubtedly due to the storms that raged around the country over the Easter holidays. However, it apparently did not stop one set of hairy chests going out to sea. They had to be rescued when their engine failed in a Force 10 gale!

TABLE 1

INCIDENTS BY MONTH

October 1993	14
November 1993	9
December 1993	8
January 1994	9
February 1994	15
March 1994	14
April 1994	39
May 1994	48
June 1994	62
July 1994	70
August 1994	43
September 1994	31