# 1992 Report on Diving Accidents & Fatalities

DAN

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Direct financial support for this report was provided by the National Oceanic and Atmospheric Administration (NOAA) and the Diving Equipment Manufacturers Association (DEMA). DAN also recognizes the dive clubs, stores, instructors, and many individual members who support DAN and diving safety.

Copies of this report may be purchased for $15, which includes postage within the United States. Copies of reports from previous years are also available by contacting the Membership department at the address given below.

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*1992 Report on Diving Accidents and Fatalities*

# Acknowledgments

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# What is DAN?

The Divers Alert Network (DAN) is an organization which originated in the United States and is dedicated to the safety of recreational scuba diving. DAN is a 501(c)3 not-for-profit organization. DAN is a membership association whose members include individual divers, sponsoring dive clubs, retail scuba operators, equipment manufacturers, scuba certification agencies, and special individuals who donate their services, time and money to support diving safety. DAN safety services and DAN scuba diving research are financially supported by membership dollars.

**DAN's mission is to enhance diving safety for recreational divers by helping them to avoid injury and provide assistance when injuries occur.**

DAN's mission is to enhance diving safety for recreational divers by helping them to avoid injury and provide assistance when injuries occur. DAN supports this mission by the following:

**First:** Providing information on health/safety issues in scuba diving to divers, the general public and physicians.

**Second:** Providing emergency assistance for the evaluation, transportation and treatment of injured divers.

**Third:** Collecting, analyzing and publishing data on diving accidents and fatalities.

DAN is the largest diving safety organization in the world, with approximately 100,000 individual and family members. In 1991 DAN organized the first international federation of diving safety organizations (IDAN). The goals are to provide worldwide assistance for medical and safety information, air evacuation, and acceptance of dive accident insurance programs. Organizations now exist under IDAN for DAN Europe, DAN Japan, and potentially DES/DAN Australia and DES/DAN New Zealand.

Divers Alert Network is best known in the diving community for its medical emergency and advisory telephone services to recreational divers and physicians.

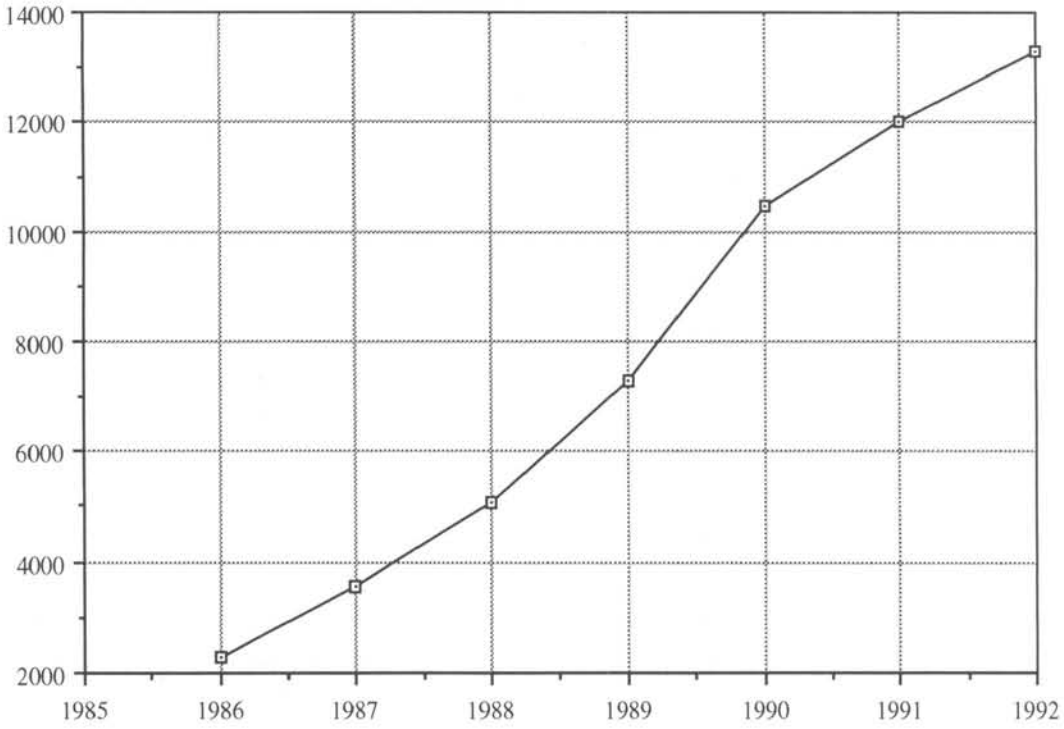
## Safety Services

**24-Hour Medical Emergency Hotline** — (919) 684-8111
DAN maintains a 24-hour emergency service 365 days a year to provide injured divers with medical consultations and referrals.

**Non-Emergency Advisory Line** — (919) 684-2948
DAN maintains an information hotline to provide answers to commonly asked questions about scuba diving medicine and safety. Calls are answered 9 a.m. to 5 p.m., Eastern Time, Monday through Friday, except holidays.

***These telephone services are totally supported by membership dollars and are provided free to all callers.*** The combined telephone services now receive over 14,000 calls annually.

**Emergency and Information Combined Telephone Call Volume**



**DAN provides courses for divers, instructors and physicians who wish to increase their awareness and understanding of scuba diving injuries and treatment.**

**Diving Safety Courses**
DAN provides courses for divers, instructors, and physicians who wish to increase their awareness and understanding of scuba diving injuries and treatment. Several hundred divers attend DAN's one-day courses, and over 1,500 physicians have been introduced to diving medicine through DAN's one-week seminars. The DAN *Oxygen First Aid in Dive Accidents* program trained 1,850 oxygen providers and 280 instructors, in 1991, the first year it was offered. DAN has now trained over 20,000 providers, over 1,500 instructors, and 150 oxygen instructor trainers worldwide.

## Membership Services

Divers Alert Network is supported primarily by its membership, with over 80 percent of its operating funds coming from member dues. Small grants, donations and limited product sales help make up the other 20 percent. The Membership department provides several services in return for the nominal dues paid, including the following.

**Safe Diver Information Kit**
This contains DAN's *Underwater Diving Accident Manual*, decals and membership cards sent to every new member.

***Alert Diver***
This is DAN's bimonthly publication that serves as a forum for ideas and information relating to diving safety, education, and practice.

**Assist America**
DAN members can access a global emergency evacuation service by calling Regional Coordination Centers found on their DAN membership card. A DAN member traveling more than 100 miles from home, whether insured or not, can be evacuated, at no cost to the member, from anywhere in the world to an appropriate medical facility in the event of an accident or illness.

**Accident Insurance**
DAN pioneered and implemented the first diving injury insurance for recreational divers in the United States. For those who choose this benefit, payment for emergency treatment is assured. DAN members are covered anywhere in the world for all in-water injuries.

# DAN Research

***Annual Report on Scuba Diving Accidents***

DAN collects the details of recreational dive injuries and fatalities. This data is analyzed for common injury trends and divided into descriptive population statistics.

**Diver Safety Surveys**

Surveys have been done to study the possible risk factors of diseases contraindicated by diving. In this way it may be possible to quantify the risk of diving with these conditions.

**Research Projects**

DAN's research projects presently include the Flying After Diving (FAD) study and the Dive Profile Database (DPD) study. For the FAD study, volunteer test subjects are exposed to depth followed by altitude in order to investigate the risk associated with flying after diving. The DPD study is still in the developmental stage. DAN is currently testing software and data collection protocol. This program is expected to be launched in early 1995.

**DAN members can access a global emergency evacuation service by calling Regional Coordination Centers found on their DAN membership card.**

# Introduction to Scuba Accidents

Scuba diving, like most other recreational sports, has a potential for personal injury. The *1992 Report on Diving Accidents and Fatalities* is the sixth annual report published by Divers Alert Network to examine injuries in recreational scuba diving in North American residents. Approximately one-half of all known decompression illness cases which occurred in 1992 to U.S. citizens is described in this report. Although the known number of treated cases of decompression illness is reasonably accurate, there are probably additional cases — most likely mild — which were not recognized or treated, and therefore not reported.

**Approximately one-half of all known decompression illness cases which occurred in 1992 to U.S. citizens is described in this report.**

One of the aims of epidemiological analysis is to establish an estimate of risk. In order to do so for diving, a knowledge of the number of dives performed by recreational divers would be required. Divers frequently do not report their profiles when they have symptoms of decompression illness. Only crude estimates of the number of divers can be made, because scuba training organizations do not publish the exact number of new U.S. divers each year, and not all certified divers remain active. Some estimates of risk do exist for divers other than U.S. recreational participants, but an accurate study of diving risk within the United States will have to await further studies.

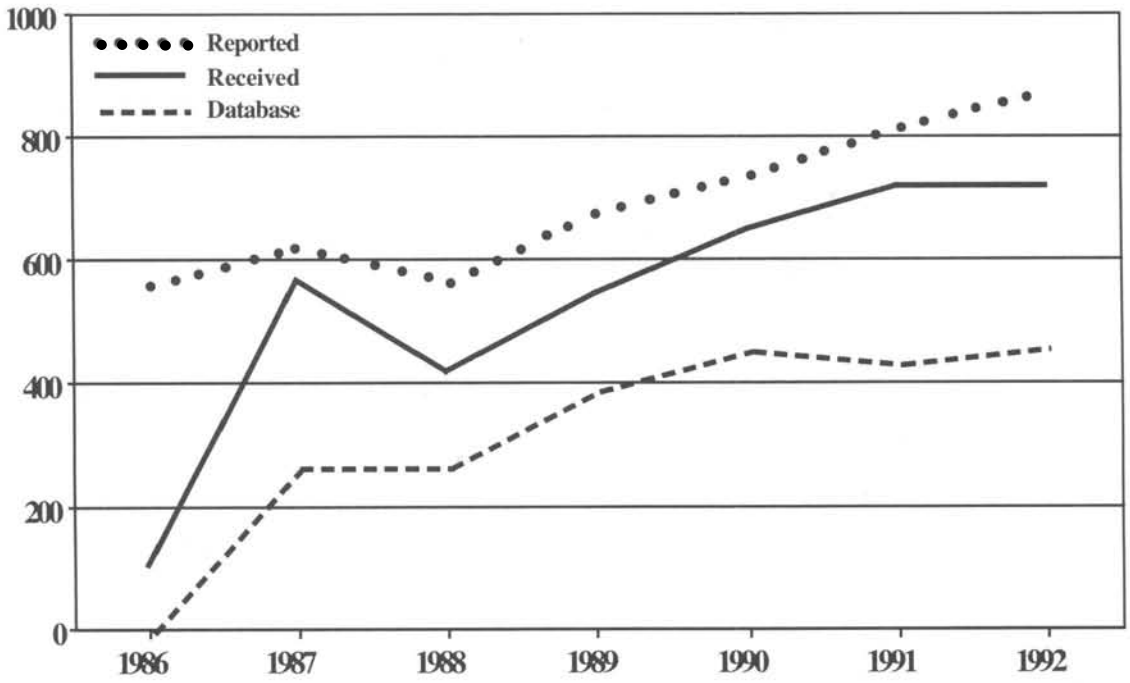
While no accurate estimates exist for the U.S. recreational popula-

**Figure 1.1 Estimated Range of Decompression Illness in Scuba Diving**

| Estimated Participants* | 1992 Reported Injuries | Estimated Injury per Diver | 1991 Reported Injuries | Estimated Injury per Diver |
|---|---|---|---|---|
| 1,500,000 | 876 | 1/1700 | 820 | 1/1800 |
| 2,000,000 | 876 | 1/2300 | 820 | 1/2400 |
| 2,500,000 | 876 | 1/2900 | 820 | 1/3000 |
| 3,000,000 | 876 | 1/3400 | 820 | 1/3700 |
| 3,500,000 | 876 | 1/4000 | 820 | 1/4300 |

** The risk per dive is unknown because there are no statistics on the number of dives made by each participant.*

## Figure 1.2 Total Number of Cases Reported Received and Completed by DAN




tion, estimates have been made for the risk in other populations. Hahn[1] has estimated that in members of the German Sport Divers Association the risk of decompression illness is 1/52,600 dives. This compares with Overland's estimates of 1/15,094 in commercial divers performing no-stop dives while breathing air.[1] Wilmshurst (1990) has estimated the risk in members of the British Sub Aqua Club at between 1/10,000 and 1/20,000 dives.[2]

Figure 1.1 provides estimates for the number of participants and the number of reported injuries. The number of participants is representative of various estimates by groups such as DAN, University of Rhode Island, the National Sporting Goods Association and others who have attempted to quantify active participants. The injuries are based on the reported number of cases treated by hyperbaric chambers across the United States and the Caribbean. The total number of cases reported received and completed by DAN is compared in Figure 1.2.

**The injuries are based on the reported number of cases treated by hyperbaric chambers across the United States and the Caribbean.**

## Case Collection

Divers Alert Network utilizes a network of hyperbaric chambers around the world to report decompression illness (DCI) injuries. DAN is assisted in this effort by Regional Coordinators who are in contact with hyperbaric treatment centers in their area and also

collect dive accident reports which are sent into DAN. Regional Coordinators also assist in directing injured divers to area medical centers for evaluation and treatment.

DAN receives most of its accident forms directly from chambers who have assisted DAN by completing them. There are a few hyperbaric chambers which do not participate in the reporting process. Others rely on the patient to fill out the form and send it to DAN. Thus, the number of actual cases received at DAN is less than the total number treated.

Each year more direct referrals are made through the telephone services of DAN to hyperbaric facilities. The increased number of emergency and information calls recorded each year are mirrored by the increasing number of treated accidents. The number of treated injuries reported to DAN increased by 6.7 percent in 1992. The overall increase in combined calls to DAN was 9.7 percent.

**There are no breath-hold divers, mixed-gas, or commercial divers — other than scuba instructors providing instruction — included in the injury report.**

The number of referrals and follow up by DAN's medical staff has led to more individuals with symptoms of DCI being referred for evaluation and treatment. This system of referral has proven to be effective in assisting injured divers and collecting cases for review each year.

Divers treated at more than one hyperbaric facility are only counted once unless there was a second separate episode of DCI in the calendar year. All injured divers were residents of North America at the time of their injury. There are no breath-hold divers, mixed-gas, or commercial divers — other than scuba instructors providing instruction — included in the injury report.

By September 1, 1993, DAN had received 720 DAN Diving Accident Reporting Forms. Of these, 465 forms were completed and included in the DAN computer database. Two hundred fifty-five (255) cases were excluded because they were commercial (54), didn't contain enough information, or were not considered DCI (112) (i.e. ear barotrauma, pulled muscles, marine life envenomation). Also excluded are a small number of cases known to be in litigation and cases where follow-up was not possible (89).

Figure 1.2 shows the case reporting and collection trend since 1986. The top dotted line indicates the total number of cases treated in 1992. The middle solid line represents the total number of cases sent to DAN for review. The bottom dashed line represents the total

number of cases which were completed, verified and entered into the 1992 accident database. Since the first annual report in 1987, DAN has reported on 43 to 62 percent of all divers treated. The 1992 report represents 53 percent of the total number of divers treated.

Once a case is received it is logged into the DAN database. If the case is recreational scuba, decompression-related, and has missing or incongruent information, the person is contacted by a DAN medical information specialist. If a patient has residual symptoms, he or she is contacted by telephone for up to three months or until they no longer have residual symptoms. The names and identifying personal information are confidential and are not available to anyone outside of DAN research and medical staff. Accident data cannot be used to imply individual fault or blame in determining the cause of scuba injuries. The number of individuals with decompression illness (DCI) who did not seek medical attention, or who were not referred for treatment is unknown.

**Accident data cannot be used to imply individual fault or blame in determining the cause of scuba injuries.**

Four hundred and sixty-five (465) cases diagnosed as DCI were included in the DAN database for 1992, which were complete and verified. A case was considered complete if most of its fields held a response. In the case where a question is blank, the table holds a *frequency missing* = '*x*,' where '*x*' is the number of cases in the database that did not respond to that question. In other places, there is no *frequency missing* listed, there is an '*n*' followed by a number. The '*n*' and number represent the population size or the number of people in that table or graph.

870
176

877

Percentages were rounded to the nearest tenth or hundredth. Many tables have categories which include very few responses resulting in a small number (number of respondents replying Yes) divided by a large number (total number of respondents). This leads to occasional rounding errors and percentages totalling more than 100 percent. A copy of the DAN Diving Accident Reporting Form which is used to gather the information present in this report is presented in Appendix B.

Figure 1.3 shows a breakdown of decompression illness by conventional diagnosis. These diagnoses are as follows: Type I decompression sickness (DCS-I), which refers to pain only, skin bends, or fatigue; Type II decompression sickness (DCS-II), which includes neurological and cardiorespiratory bends, and arterial gas embolism (AGE), which represents arterialized gas bubbles primarily associated with immediate cerebral symptoms. These diagnoses were primarily based upon the diagnoses of the treating physician.

# Figure 1.3 Total Reported Cases by Year and Region

| 1992 | SW | NW | MW | GU | PA | NE | SE** | TOTALS |
|---|---|---|---|---|---|---|---|---|
| DCS-I | 25 | 17 | 20 | 24 | 21 | 43 | 82 | 225 |
| DCS-II | 59 | 47 | 27 | 59 | 63◆ | 24 | 276 | 557 |
| AGE | 11 | 6 | 4 | 10 | | 6 | 39 | 76 |
| No case breakdown | | | | | | | 13 | 13 |
| **TOTALS** | **95** | **70** | **51** | **93** | **84** | **73** | **410** | **876*** |

| 1991 | SW | NW | MW | GU | PA+ | NE | SE** | TOTALS |
|---|---|---|---|---|---|---|---|---|
| DCS-I | 34 | 12 | 6 | 32 | * | 40 | 109 | 233 |
| DCS-II | 83 | 21 | 21 | 22 | 1 | 49 | 240 | 437 |
| AGE | 26 | 2 | 8 | 9 | * | 6 | 36 | 87 |
| No DX reported | | | | | 57 | | | 57 |
| No Treatment++ | 1 | | | | 1 | | 4 | 6 |
| **TOTALS** | **144** | **35** | **35** | **63** | **59** | **95** | **389** | **820*** |

| 1990 | SW | NW | MW | GU | PA+ | NE | SE** | TOTALS |
|---|---|---|---|---|---|---|---|---|
| DCS-I | 31 | 8 | 17 | 31 | | 28 | 111 | 243 |
| DCS-II | 60 | 8 | 10 | 37 | | 34 | 193 | 346 |
| AGE | 13 | 1 | 2 | 7 | | 15 | 58 | 118 |
| No DX reported | | | | | 31 | | | 31 |
| No Treatment++ | | | | | | | | |
| **TOTALS** | **104** | **17** | **29** | **75** | **31** | **77** | **362** | **738*** |

| 1989 | SW | NW | MW | GU | PA+ | NE | SE** | TOTALS |
|---|---|---|---|---|---|---|---|---|
| DCS-I | 48 | 12 | 18 | 11 | | 14 | 78 | 181 |
| DCS-II | 64 | 15 | 17 | 29 | | 47 | 156 | 328 |
| AGE | 35 | 3 | 3 | 1 | | 4 | 65 | 111 |
| No DX reported | | | | | 58 | | | 58 |
| No Treatment++ | | | | | | | | |
| **TOTALS** | **147** | **30** | **38** | **41** | **58** | **65** | **299** | **678*** |

*++ No treatment represents cases with no treatment, refused treatment, or spontaneous resolution.*

# Figure 1.3 *(Continued)* Total Reported Cases by Year and Region

| 1988 | SW | NW | MW | GU | PA+ | NE | SE** | TOTALS |
|---|---|---|---|---|---|---|---|---|
| DCS-I | 14 | 9 | 11 | 13 | | 22 | 68 | 137 |
| DCS-II | 43 | 27 | 10 | 25 | | 32 | 151 | 288 |
| AGE | 25 | 6 | 2 | 1 | | 10 | 38 | 82 |
| DCS-AGE combined | 1 | | | 4 | | | 5 | 10 |
| No DX reported | | | | | 36 | | | 36 |
| No Treatment++ | | 3 | | 1 | 1 | 2 | 5 | 12 |
| **TOTALS** | **83** | **45** | **23** | **44** | **37** | **66** | **267** | **565*** |

| 1987 | SW | NW | MW | GU | PA+ | NE | SE** | TOTALS |
|---|---|---|---|---|---|---|---|---|
| DCS-I | 15 | 4 | 2 | 15 | | 30 | 61 | 127 |
| DCS-II | 58* | 25 | 12 | 20 | | 26 | 199 | 340* |
| AGE | 20 | 4 | 2 | 6 | | 6 | 59 | 97 |
| No DX reported | | | | | 38 | | | 38 |
| No Treatment++ | 2 | | | | | 3 | 17 | 22 |
| **TOTALS** | **95** | **33** | **16** | **41** | **38** | **65** | **336** | **624*** |

| 1986 | SW | NW | MW | GU | PA+ | NE | SE** | TOTALS |
|---|---|---|---|---|---|---|---|---|
| DCS-I | | 6 | 2 | 1 | | | 68 | 77 |
| DCS-II | 69* | 11 | 13 | 8 | 7 | 33 | 133 | 274* |
| AGE | 28 | 2 | | | | 10 | 41 | 81 |
| No DX reported | | | | | 25 | | 97 | 122 |
| No Treatment++ | 3 | | | | | 1 | 4 | 8 |
| **TOTALS** | **100** | **19** | **15** | **9** | **32** | **44** | **343** | **562*** |

* *Represents DCS Types I and II cases combined.*
** *SE includes Caribbean Basin*
◆ *Represents DCS Type II and AGE cases combined.*
\+ *Hawaii only reports number of cases treated.*
++ *No Treatment represents cases with no treatment, refused treatment, or spontaneous resolution.*

## Figure 1.4 Total Cases Treated & Reported in 1992 by Region

**Figure 1.4 shows the total cases treated in 1992 by DAN region and the state where treatment was received.**

| Southwest Region | DCS-I | DCS-II | AGE | TOTALS |
|---|---|---|---|---|
| Arizona | 0 | 4 | 0 | 4 |
| California | 22* | 51 | 11 | 84 |
| Utah | 3 | 4 | | 7 |
| **TOTALS** | **25** | **59** | **11** | **95** |

** 12 of these cases are combined DCS-I and II*

| Northwest Region | DCS-I | DCS-II | AGE | TOTALS |
|---|---|---|---|---|
| Montana | 1 | 0 | 0 | 1 |
| Oregon | 2 | 7 | 0 | 9 |
| Washington | 14 | 40 | 6 | 60 |
| **TOTALS** | **17** | **47** | **6** | **70** |

| Midwest Region | DCS-I | DCS-II | AGE | TOTALS |
|---|---|---|---|---|
| Illinois | 1 | 0 | 1 | 2 |
| Indiana | 2 | 3 | 0 | 5 |
| Kentucky | 1 | 1 | 0 | 2 |
| Michigan | 12 | 2 | 0 | 14 |
| Minnesota | 2 | 8 | 1 | 11 |
| Ohio | 0 | 7 | 1 | 8 |
| Wisconsin | 1 | 7 | 1 | 9 |
| **TOTALS** | **19** | **28** | **4** | **51** |

| Gulf Region | DCS-I | DCS-II | AGE | TOTALS |
|---|---|---|---|---|
| Kansas | 2 | 0 | 0 | 2 |
| Louisiana | 8 | 17 | 2 | 27 |
| Mississippi | 0 | 1 | 0 | 1 |
| Missouri | 1 | 0 | 1 | 2 |
| New Mexico | 2 | 1 | 0 | 3 |
| Oklahoma | 5 | 1 | 2 | 8 |
| Texas | 6 | 39 | 5 | 50 |
| **TOTALS** | **24** | **59** | **10** | **93** |

| Pacific Region | DCS-I | DCS-II & AGE | TOTALS |
|---|---|---|---|
| Hawaii | 21 | 63 | 84 |
| **TOTALS** | **21** | **63** | **84** |

**Figure 1.4** ***(Continued)*** **Total Cases Treated & Reported in 1992 by Region**

| Northeast Region | DCS-I | DCS-II | AGE | TOTALS |
|---|---|---|---|---|
| Connecticut | 9 | 1 | 0 | 10 |
| Maine | 2 | 3 | 1 | 6 |
| Maryland | 24 | 2 | 0 | 26 |
| New York | 1 | 11 | 0 | 12 |
| Pennsylvania | 7 | 5 | 5 | 17 |
| Virginia | 0 | 2 | 0 | 2 |
| **TOTALS** | **43** | **24** | **6** | **73** |

| Southeast Region | DCS-I | DCS-II | AGE | TOTALS |
|---|---|---|---|---|
| Alabama | 6 | 8 | 0 | 14 |
| Florida | 53* | 157 | 18 | 228 |
| Georgia | 6 | 2 | 0 | 8 |
| North Carolina | 5 | 21 | 3 | 29 |
| South Carolina | 5 | 2 | 1 | 8 |
| Tennessee | 2 | 1 | 0 | 3 |
| **TOTALS** | **77** | **191** | **22** | **290** |

**4 cases were not classified.*

| Caribbean Basin | DCS-I | DCS-II | AGE | TOTALS |
|---|---|---|---|---|
| Bahamas-IUNEXSO* | | | | 3 |
| Barbados | 1 | 3 | 1 | 5 |
| Belize | 2 | 13 | 1 | 16 |
| Bermuda | 0 | 5 | 1 | 6 |
| Bonaire | 0 | 2 | 0 | 2 |
| Cancun | 0 | 1 | 0 | 1 |
| Cayman | 3 | 18 | 5 | 26 |
| Cozumel | 1 | 14 | 4 | 19 |
| Honduras | 2 | 12 | 1 | 15 |
| Jamaica* | | | | 3 |
| Panama | 0 | 1 | 1 | 2 |
| Saba | 0 | 8 | 0 | 8 |
| St. Thomas | 0 | 8 | 3 | 11 |
| Turks and Caicos* | | | | 3 |
| **TOTALS** | **9** | **85** | **17** | **120** |

** These chambers did not classify their cases*

**Figure 1.4 represents the total number of cases reported to DAN in 1992.**

## Figure 1.5 Accidents by Country & U.S. Territories

| Country | Frequency | Percentage |
|---|---|---|
| West Indies | 1 | 0.2 |
| Jamaica | 1 | 0.2 |
| British Virgin Islands | 1 | 0.2 |
| Barbados | 2 | 0.4 |
| Canada | 2 | 0.4 |
| Truk | 2 | 0.4 |
| Bonaire | 4 | 0.9 |
| Turks & Caicos | 6 | 1.3 |
| Belize | 6 | 1.3 |
| Other | 7 | 1.5 |
| Antilles | 8 | 1.7 |
| Bahamas | 10 | 2.1 |
| U.S. Territories | 12 | 2.6 |
| Honduras | 18 | 3.9 |
| Caymans | 20 | 4.3 |
| Mexico | 36 | 7.8 |
| USA | 329 | 70.8 |
| **TOTAL** | **465** | **100.0** |

**Figures 1.5 and 1.6 show a second breakdown of dive location by country and state ...**

Figure 1.4 shows the total cases treated in 1992 by DAN region and the state where treatment was received. The Caribbean Basin area is included in the Southeast totals in Figure 1.3 for all years. In Figure 1.4 the Caribbean Basin is represented separately. Figure 1.4 represents the total number of cases reported to DAN in 1992.

Figures 1.5 and 1.6 show a second breakdown of dive location by country and state for the 465 injury cases used for analysis in this report. This table does not necessarily indicate treatment location.

[1] Proceedings of Repetitive Diving Workshop, Duke University Medical Center, American Academy of Underwater Sciences March 18-19, 1991.

[2] Wilmshurst, P. (1990). Analysis of decompression accidents in amateur divers. Progress in Underwater Science, The Journal of the Underwater Association, 15, 31-37.

## Figure 1.6 Accidents by U.S. States & Territories

| State | Frequency | Percent |
|---|---|---|
| Arkansas | 1 | 0.3 |
| Indiana | 1 | 0.3 |
| Maine | 1 | 0.3 |
| West Virginia | 1 | 0.3 |
| Wyoming | 1 | 0.3 |
| Colorado | 2 | 0.6 |
| Delaware | 2 | 0.6 |
| Minnesota | 2 | 0.6 |
| Nevada | 2 | 0.6 |
| South Carolina | 2 | 0.6 |
| Utah | 2 | 0.6 |
| Alabama | 3 | 0.9 |
| Georgia | 3 | 0.9 |
| Louisiana | 3 | 0.9 |
| Maryland | 3 | 0.9 |
| New Jersey | 3 | 0.9 |
| Illinois | 4 | 1.2 |
| Ohio | 4 | 1.2 |
| Virginia | 4 | 1.2 |
| Massachusetts | 5 | 1.5 |
| Wisconsin | 5 | 1.5 |
| New York | 8 | 2.3 |
| Hawaii | 9 | 2.6 |
| Missouri | 9 | 2.6 |
| U.S. Territories | 12 | 2.9 |
| Texas | 11 | 3.2 |
| Michigan | 13 | 3.8 |
| North Carolina | 18 | 5.3 |
| California | 27 | 7.9 |
| Washington | 38 | 11.1 |
| Florida | 142 | 41.6 |
| **TOTAL** | **341** | **99.5** |

*Frequency missing = 125*

**... for the 465 injury cases used for analysis in this report. This table does not necessarily indicate treatment location.**

# Injured Diver Characteristics

**For the first time there were three reports on injured individuals who were age 65 or older.**

Figure 2.1 demonstrates the wide age distribution range of the 1992 cases. This age distribution is consistently reported and appears to be a valid representation of the population of active scuba divers.

Approximately 75 percent of scuba injuries occur in individuals between 25 and 44 years of age. For the first time there were three reports on injured individuals who were age 65 or older. The number of junior open-water divers decreased from the high of six in 1991 to one this year, which is the usual case number reported.

Figure 2.2 shows a slight increase in the percentage of females reported in this year's database but is approximately equal to the 27 percent reported in the 1989 DAN membership prospective survey.

## Figure 2.1 Age Distribution of Accident Cases

| Age | 1992 Percent | 1991 Percent | 1990 Percent | 1989 Percent | 1988 Percent | 1987 Percent |
|---|---|---|---|---|---|---|
| 10-14 | 0.2 | 1.4 | 0.2 | 0.3 | 0.7 | 0.7 |
| 15-19 | 2.8 | 2.8 | 3.3 | 2.8 | 1.5 | 4.1 |
| 20-24 | 10.1 | 7.8 | 9.0 | 8.2 | 10.1 | 10.4 |
| 25-29 | 16.1 | 16.1 | 22.9 | 24.0 | 23.1 | 19.3 |
| 30-34 | 22.8 | 23.7 | 22.5 | 22.0 | 23.9 | 23.3 |
| 35-39 | 20.9 | 22.3 | 20.5 | 14.6 | 14.6 | 22.2 |
| 40-44 | 14.0 | 12.6 | 11.8 | 12.3 | 13.1 | 11.9 |
| 45-49 | 7.5 | 7.8 | 5.0 | 7.4 | 7.1 | 4.1 |
| 50-54 | 2.6 | 3.0 | 3.1 | 4.3 | 4.1 | 1.1 |
| 55-59 | 0.9 | 1.4 | 1.1 | 2.8 | 0.7 | 1.1 |
| 60-64 | 1.5 | 1.1 | 0.7 | 1.3 | 1.1 | 1.9 |
| >=65 | 0.6 | – | – | – | – | – |
| **TOTALS** | **100.0** | **100.0** | **100.1** | **100.0** | **100.0** | **100.0** |
| | *n* = 465 | *n* = 436 | *n* = 458 | *n* = 391 | *n* = 268 | *n* = 270 |

## Figure 2.2 Sex of 1987-1992 Accident Cases

| Sex | 1992 Percent | 1991 Percent | 1990 Percent | 1989 Percent | 1988 Percent | 1987 Percent |
|---|---|---|---|---|---|---|
| Female | 29.2 | 25.2 | 26.4 | 26.1 | 21.6 | 24.1 |
| Male | 70.8 | 74.8 | 73.6 | 73.9 | 78.4 | 75.9 |
| **TOTAL** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |
| | *n* = 465 | *n* = 437 | *n* = 459 | *n* = 391 | *n* = 268 | *n* = 270 |

Figure 2.3 compares the diving experience of males and females by the total number of dives completed up to the time of injury. Twenty-seven percent of the injuries in male divers occurred in the first year of diving. Twenty percent of injuries in males occurred to those with a total experience of 20 or less dives. Sixteen percent of injuries in males occurred in the first year of diving and with 20 or less dives.

The distribution of injuries between male and female divers is different. Forty-nine percent of all injuries in female divers occurred in the first year of diving. This is roughly one out of every two female injuries. Thirty-seven percent of the injuries in female divers occurred to those that had experienced 20 or less dives. Thirty-one percent of injuries occurred in the first year of diving and with 20 or less dives. Among those individuals in the injury population, women appear to be underrepresented in the category of injuries in individuals with 10 years of experience or more. The data show only 9 percent of female injuries were in this category, compared to 27 percent of all injuries in male divers. Possibly there are fewer women than men with this length of diving experience. This is consistent with the hypothesis that females and males have approximately the same risk of DCI.

Figure 2.4 compares the distribution of diver injuries by years of diving for male and female divers. The majority of injuries among females consistently occurs in the first two years of diving. Three out of four injuries — 75 percent — among females occur in the first five years of experience. Fifty-eight percent of the male injuries have occurred in the same time period. It is impossible to interpret this data fully without knowing the distribution of non-injured divers. However, the data suggest that divers who have DCI early in their diving experience may be predisposed to injury, possibly by virtue of inexperience and improper technique.

**New divers typically make up 38 to 40 percent of all the cases in DAN's database. On average, about two out of every 10 new divers exceeded their no-decompression table limits.**

# Figure 2.3 1992 Diver Experience

| **Male** | **Total Lifetime Dives** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Years Diving | 0-20 | 21-40 | 41-60 | 61-80 | 81-100 | 100-120 | 121+ | TOTALS |
| 0-1 | 52 | 14 | 8 | 4 | 4 | 0 | 4 | 86 |
| 2-3 | 7 | 12 | 8 | 7 | 7 | 2 | 14 | 57 |
| 4-5 | 2 | 3 | 9 | 3 | 7 | 0 | 19 | 43 |
| 6-7 | 1 | 4 | 1 | 2 | 1 | 1 | 17 | 27 |
| 8-9 | 0 | 0 | 3 | 1 | 2 | 0 | 10 | 16 |
| 10-11 | 1 | 0 | 1 | 1 | 0 | 0 | 15 | 18 |
| 12-13 | 0 | 0 | 0 | 0 | 1 | 1 | 8 | 10 |
| 14-15 | 0 | 0 | 0 | 2 | 1 | 0 | 13 | 16 |
| 16-17 | 0 | 0 | 0 | 1 | 1 | 0 | 11 | 13 |
| 18-19 | 0 | 0 | 0 | 0 | 1 | 0 | 6 | 7 |
| 20-21 | 0 | 1 | 0 | 0 | 0 | 0 | 23 | 24 |
| **TOTALS** | **63** | **34** | **30** | **21** | **25** | **4** | **140** | **317** |

| **Female** | **Total Lifetime Dives** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Years Diving | 0-20 | 21-40 | 41-60 | 61-80 | 81-100 | 100-120 | 121+ | TOTALS |
| 0-1 | 42 | 16 | 5 | 2 | 1 | 0 | 0 | 66 |
| 2-3 | 3 | 7 | 6 | 2 | 2 | 0 | 5 | 25 |
| 4-5 | 4 | 1 | 1 | 2 | 0 | 0 | 2 | 10 |
| 6-7 | 1 | 1 | 0 | 1 | 2 | 1 | 6 | 12 |
| 8-9 | 0 | 1 | 0 | 0 | 1 | 0 | 7 | 9 |
| 10-11 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 12-13 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 4 |
| 14-15 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 3 |
| 16-17 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| 18-19 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 20-21 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| **TOTALS** | **50** | **26** | **12** | **8** | **7** | **1** | **30** | **134** |

## Figure 2.4 Number of Divers by Years of Diving Experience

| Years Diving | Sex | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 |
|---|---|---|---|---|---|---|---|
| < 2 Years | Male | 86 | 93 | 81 | 37 | 35 | 56 |
| | Female | 66 | 50 | 55 | 21 | 25 | 29 |
| 2 to 5 Years | Male | 100 | 104 | 106 | 79 | 62 | 46 |
| | Female | 35 | 41 | 44 | 32 | 17 | 14 |
| 6 to 9 Years | Male | 43 | 27 | 55 | 36 | 37 | 31 |
| | Female | 21 | 7 | 8 | 9 | 12 | 14 |
| ≥ 10 Years | Male | 88 | 103 | 96 | 98 | 76 | 72 |
| | Female | 12 | 12 | 14 | 8 | 3 | 8 |

Figure 2.5 shows the certification level of individuals in the database for the last five years. Forty-six percent of all injuries occur in divers with a basic, or open-water, certification. This finding is consistent for the reporting years in Figure 2.5.

There was an increase in the number and percentage of accidents in individuals with advanced open-water training. This increase represents 45 more advanced divers than in the previous year.

The last two years have shown a small increase in the number of divemasters with decompression illness. In 1991 the highest number of divemasters (40) and the highest percentage of divemasters injured were reported.

The number of instructors with decompression sickness has remained approximately 10 percent, or one out of every 10 decompression illness injuries.

The number of student injuries is relatively small. There are also some individuals who dive without proper certification, and who experience a DCI incident, and require treatment.

**There was an increase in the number and percentage of accidents in individuals with advanced open-water training.**

## Figure 2.5 Certification Level of 1988-1992 Accident Cases

| Certification | Male | Female | Totals | 1992 Percent | 1991 Percent | 1990 Percent | 1989 Percent | 1988 Percent |
|---|---|---|---|---|---|---|---|---|
| Student | 6 | 4 | 10 | 2.2 | 3.0 | 0.7 | 3.1 | – |
| Basic | 13 | 13 | 26 | 5.8 | 5.9 | 10.0 | 7.7 | 13.4 |
| Open-Water | 127 | 61 | 188 | 40.4 | 43.0 | 44.0 | 41.4 | 35.4 |
| Advanced | 106 | 41 | 147 | 31.6 | 23.3 | 20.9 | 27.9 | 26.9 |
| Divemaster | 33 | 4 | 37 | 8.0 | 9.2 | 6.8 | 6.1 | 4.9 |
| Instructor | 32 | 11 | 43 | 9.2 | 11.7 | 10.5 | 10.5 | 11.2 |
| Commercial | 0 | 0 | 0 | 0.0 | 0.0 | 0.9 | 0.3 | 4.1 |
| Other | 8 | 1 | 9 | 1.9 | 2.3 | 4.6 | 1.5 | 3.0 |
| None | 3 | 1 | 4 | 0.9 | 1.6 | 1.5 | – | – |
| Unknown | 0 | 0 | 0 | 0.0 | 0.0 | 0.2 | 1.5 | 1.1 |
| **TOTALS** | **328** | **136** | **464** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |

**In 1992 a new category was added to diver analysis which shows that in 30 percent of the new diver cases, the last dive was to 80 feet or greater.**

The new diver profile traits are shown in Figure 2.6. This category includes new divers with less than two years of diving experience and those divers who have not accumulated more than 20 dives. New divers typically make up 38 to 40 percent of all the cases in DAN's database. On average, about two out of every 10 new divers exceeded their no-decompression table limits. Twelve of the 39 divers represented in this category were using computers which allow for multilevel depths.

It appears the number of new divers experiencing rapid ascents is slowly decreasing over the period of case reporting. Most new divers participate in deep diving to 80 feet or deeper.

In 1992 a new category was added to diver analysis, which shows that in 30 percent of the new diver cases, the last dive was to 80 feet or greater. On average, each year 70 percent of the new divers have made 20 dives or less.

In addition, 56 percent of these divers were not participating in what they considered to be a typical or usual dive. This means they may

## Figure 2.6 New Diver Profile Traits

| Traits | 1992 Percent | 1991 Percent | 1990 Percent | 1989 Percent | 1988 Percent |
|---|---|---|---|---|---|
| Outside Limits | 23.5 | 20.4 | 23.8 | 18.0 | 31.0 |
| Rapid Ascent | 30.5 | 38.1 | 38.1 | 43.0 | 41.0 |
| Last Dive ≥ 80 fsw | 30.3 | – | – | – | – |
| Diving ≥ 80 fsw | 58.8 | 58.9 | 64.6 | 46.0 | 61.0 |
| Square Dives | 42.0 | 60.4 | 50.8 | 51.0 | 61.0 |
| Repeat Dive | 63.5 | 56.2 | 64.6 | 59.0 | 50.0 |
| ≤ 20 Dives | 68.2 | 70.9 | 76.8 | 72.0 | 75.0 |
| *Frequency Missing* = 287 | *n* = 178 | *n* = 169 | *n* = 181 | *n* = 114 | *n* = 78 |

have experienced their first open-ocean dive, first dive trip, a dive in adverse or rough weather conditions, or they may have been participating in their deepest dive.

No precise relationship can be established between current and past medical conditions and a specific type of decompression illness. Pre-existing musculo-skeletal problems or residual symptoms from a previous injury may complicate post-dive evaluations when the symptoms for a medical condition are similar or the same as those for DCI.

Figures 2.7 and 2.9 show that many individuals have a number of current and previous medical conditions but continue to dive. Only about 25 percent of the injured divers were actually diving with a current medical condition when they were injured. Some medical problems can limit an individual's ability to perform the required physical activity of scuba diving. Almost half of all divers in the injury population report having some health problems prior to their decompression illness.

**Almost half of all divers in the injury population report having some health problems prior to their decompression illness.**

## Figure 2.7 Current Medical History of Decompression Illness Cases for the Years 1992-1988

| Problem | 1992 | 1991 | 1990 | 1989 | 1988 |
|---|---|---|---|---|---|
| Chest-lung | 7 | 16 | 14 | 9 | 4 |
| Asthma | 8 | 5 | 8 | 6 | 5 |
| Chest-heart | 7 | 2 | 3 | 8 | 2 |
| GI/Abdomen | 14 | 11 | 12 | 9 | 4 |
| Brain | 0 | 0 | 2 | – | – |
| Spine/Back | 11 | 21 | 19 | 23 | 6 |
| Limb/joint DCS | 4 | 2 | 10 | 1 | 4 |
| Circulation/Blood | 4 | 3 | 5 | 3 | 6 |
| Neuro/Nerv system | 7 | 5 | 5 | 3 | 1 |
| Muscl/Skel system | 25 | 16 | 13 | 14 | 9 |
| Eye | 4 | 1 | 1 | 3 | 2 |
| Mental/Emotional | 10 | 8 | 9 | 6 | 6 |
| Other | 51 | 42 | 32 | 39 | 48 |
| None | 333 | 319 | 342 | 282 | 180 |
| No Response | 1 | – | – | – | – |
| **TOTALS** | **486** | **451*** | **475*** | **406*** | **277*** |

**Divers may have had more than one illness.*

## Figure 2.8 Percentage of Divers Without Current Health Problems

| Current | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 |
|---|---|---|---|---|---|---|
| Frequency | 333 | 319 | 342 | 282 | 180 | 174 |
| Percent | 71.7% | 74% | 80% | 72% | 67% | 64% |
| | n = 464 | *n* = 434 | *n* = 426 | *n* = 391 | *n* = 268 | *n* = 270 |

## Figure 2.9 Previous Illness and Diseases of Decompression Illness Cases for the Years 1992-1988

| Problem | 1992 | 1991 | 1990 | 1989 | 1988 |
|---|---|---|---|---|---|
| Chest-lung | 14 | 18 | 25 | 14 | 14 |
| Asthma | 20 | 14 | 15 | 16 | 14 |
| Chest-heart | 11 | 8 | 15 | 11 | 6 |
| GI/Abdomen | 38 | 42 | 49 | 45 | 24 |
| Brain | 4 | 2 | 6 | 2 | 3 |
| Spine/Back | 39 | 51 | 40 | 39 | 19 |
| Limb/joint DCS | 23 | 43 | 35 | 8 | 17 |
| Circulation/Blood | 9 | 5 | 3 | 6 | 4 |
| Neuro/Nerv system | 11 | 13 | 9 | 3 | 5 |
| Muscl/Skel system | 47 | 59 | 63 | 50 | 33 |
| Eye | 10 | 8 | 7 | 8 | 3 |
| Mental/Emotional | 12 | 7 | 3 | 3 | 2 |
| Other | 66 | 61 | 76 | 71 | 37 |
| None | 244 | 201 | 219 | 184 | 129 |
| No Response | 1 | – | – | – | – |
| **TOTALS** | **549** | **532*** | **565*** | **460*** | **310*** |

**Divers may have had more than one illness.*

## Figure 2.10 Percentage of Divers Without Past Health Problems

| Current | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 |
|---|---|---|---|---|---|---|
| Frequency | 244 | 201 | 219 | 184 | 129 | 131 |
| Percent | 52.6% | 46% | 48% | 47% | 48% | 48% |
| | *n* = 464 | *n* = 437 | *n* = 458 | *n* = 391 | *n* = 268 | *n* = 270 |

Figure 2.11 shows the percentage of individuals who reported being physically fit prior to their dive injury. The majority of these divers also indicated they were on a regular weekly exercise or workout schedule to maintain fitness. In general, this data indicates that the majority of these scuba divers state they are physically fit, but physical fitness does not prevent DCI. The characteristics of dives that resulted in arterial gas embolism or decompression sickness are reported in Figure 3.4 and 3.5 in Section 3.

## Figure 2.11 Reported Physical Fitness in Injured Divers

| | 1992 | 1991 | 1990 | 1989 | 1988 |
|---|---|---|---|---|---|
| Sex | Percent | Percent | Percent | Percent | Percent |
| Male | 94.5 | 90.8 | 88.5 | 93.4 | 87.6 |
| Female | 88.2 | 90.0 | 86.8 | 90.0 | 84.5 |
| **TOTAL** | **92.7** | **90.6** | **88.0** | **92.5** | **86.9** |

**... the majority of these scuba divers state they are physically fit, but physical fitness does not prevent decompression illness.**

Strenuous exercise may contribute to the development of decompression illness and is usually best avoided from one to six hours before or after scuba diving. There are many types of activities such as loading scuba tanks, carrying full scuba equipment over a long distance, recreational sporting activities, and heavy swimming which is viewed as strenuous exercise. Over the last two years, 58 to 61 percent of the injured divers reported activities or dives that required strenuous exercise on the day of injury. In 1990 and 1989 these percentages were 24 and 27 percent, respectively.

## Figure 2.12 Strenuous Exercise Before, During or After Dive in 1992

| Sex | Prior to Dive | During Dive | After Dive |
|---|---|---|---|
| Male | 66 | 195 | 30 |
| Female | 18 | 78 | 9 |
| **TOTAL** | **84** | **273** | **39** |

Figure 2.13 shows that in recent years more divers report taking prescription medication than *over-the-counter or nonprescription medications.* About 20 percent of all divers in the last two years admit to taking some over-the-counter medications. Thirty-six people were taking decongestants on dive days; 29 were taking non-

steroidal, anti-inflammatory pain relief medication; 14 were taking antihistamines; and seven were taking vitamins or minerals. Two individuals were using over-the-counter inhalers for asthma.

Birth control pills or estrogen supplements were the most common *prescription medication* taken by 40 divers. Cardiovascular or blood pressure-related medications were taken by 21 individuals; 20 divers were taking prescription antihistamines. Sixteen people were on antibiotic therapy at the time of diving, while 13 were taking anti-anxiety/antidepressant medication. Seven divers were on thyroid medication, and several divers were using malarial prophylaxes, gastric medication, topical antifungals, and nasal sprays. Many

**Strenuous exercise may contribute to the development of decompression illness and is usually best avoided from one to six hours before or after scuba diving.**

## Figure 2.13 Medication Use in Accident Cases

| 1992 Prescription Use | | Nonprescription Use | |
|---|---|---|---|
| Frequency | Percent | Frequency | Percent |
| 140 | 31.1 | 83 | 21.6 |
| $n$ = 450 | | $n$ = 385 | |

| 1991 Prescription Use | | Nonprescription Use | |
|---|---|---|---|
| Frequency | Percent | Frequency | Percent |
| 100 | 22.9 | 85 | 19.5 |
| $n$ = 437 | | $n$ = 435 | |

| 1990 Prescription Use | | Nonprescription Use | |
|---|---|---|---|
| Frequency | Percent | Frequency | Percent |
| 132 | 30.0 | 66 | 18.7 |
| $n$ = 440 | | $n$ = 353 | |

| 1989 Prescription Use | | Nonprescription Use | |
|---|---|---|---|
| Frequency | Percent | Frequency | Percent |
| 93 | 24.9 | 25 | 7.7 |
| $n$ = 374 | | $n$ = 325 | |

| 1988 Prescription Use | | Nonprescription Use | |
|---|---|---|---|
| Frequency | Percent | Frequency | Percent |
| 58 | 21.9 | 71 | 27.2 |
| $n$ = 265 | | $n$ = 261 | |

individuals were taking one or more prescribed medications along with some over-the-counter preparations.

**The percentage of alcohol use in dive accidents has remained constant. The majority of alcohol use occurs primarily on the night before diving.**

The percentage of divers reporting alcohol use in dive accidents has remained constant for five years. The majority of alcohol use occurs primarily on the night before diving. Figure 2.14 shows that at least one alcoholic beverage (wine, beer, or liquor) was consumed the night before diving in approximately 42 percent of all of the 1992 cases.

Figure 2.15 shows the number of people who consumed alcohol and how many drinks they consumed prior to beginning their last day of diving. In 1992 approximately 60 percent of those individuals who drank consumed two or less drinks the night before. Forty percent of the divers reported having three or more drinks the night before diving. Alcohol use is a concern for divers, because it may have a dehydrating effect which can limit individual ability to remove nitrogen from body tissues. Alcohol also has numerous secondary effects on divers, such as nausea, hangover, fatigue, and impaired mental and physical performance.

Figure 2.16 shows the number of individuals who began their dive day already suffering with a temporary medical condition or recent recreational drug use. Medical conditions and recreational habits such as those shown in Figure 2.16 can lead to a decrease in physical and mental abilities.

**Pre-dive fatigue or lack of sleep on the night before diving has been consistently reported in about one-third of all cases of decompression illness in the database. Fatigue, like other medical conditions, can also impair individual performance.**

Pre-dive fatigue or lack of sleep on the night before diving has been consistently reported in about one-third of all cases of decompression illness in the database. Fatigue, like other medical conditions, can also impair individual performance. Fatigue is one of the top six symptoms of decompression sickness and can be a precursor to more serious symptoms. In the past two years, males have reported more fatigue prior to their last day of diving than females.

## Figure 2.14 Percentage of Alcohol Use in 1988-1992 Accident Cases

| Time of Use | 1992 | 1991 | 1990 | 1989 | 1988 |
|---|---|---|---|---|---|
| Night before | 37.7 | 36.6 | 39.9 | 40.9 | 43.3 |
| Pre-dive | 1.1 | 2.3 | 8.7 | 1.8 | 1.5 |
| Between dives | 1.7 | 1.8 | 1.1 | 1.9 | 2.2 |
| Post-dive | 13.2 | 14.2 | 16.1 | 15.6 | 10.4 |
| None | 55.4 | 56.3 | 53.6 | 48.3 | 51.9 |
| *Frequency Missing = 3* | *n = 462* | *n = 437* | *n = 459* | *n = 391* | *n = 268* |

** Some divers engage in drinking in more than one category.*

## Figure 2.15 Alcohol Use Up to 12 Hours Before Diving in 1992

| | Number of Drinks | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **Total** |
| **1992** | 47 | 59 | 16 | 23 | 6 | 13 | 13 | **177** |
| **1991** | 32 | 53 | 30 | 16 | 11 | 9 | 12 | **163** |
| **1990** | 43 | 64 | 19 | 20 | 7 | 10 | 16 | **182** |
| **1989** | 39 | 49 | 24 | 23 | 6 | 13 | 10 | **164** |
| **1988** | | | | | | | | **120** |

## Figure 2.16 1992 Nausea, Hangover, Diarrhea, and Recreational Drug Use

| Sex | Nausea | Hangover | Diarrhea | Drug Use |
|---|---|---|---|---|
| Male | 9 | 7 | 5 | 10 |
| Female | 3 | 2 | 3 | 0 |
| **TOTALS** | **12** | **9** | **8** | **10** |

# Accident Dive Profile

**The majority of injuries occurred within a month of the last safe dive made by the particular diver. This would seem to indicate that most divers in the accident database dive fairly often.**

The dive profile section is composed of tables and charts which demonstrate the type of underwater activity being performed, as well as various attributes of the dives when a diving incident occurred. Data from four previous years is presented in many of the tables to indicate any changes. The actual dive profile information is limited and should only be considered in relation to the various attributes of dives recorded by DAN.

The vast majority of divers suffer their injuries while sightseeing. Wreck diving and those undergoing training were the next two most common activities of those in reported cases (Figure 3.1)

The majority of injuries occurred within a month of the last safe dive made by the particular diver. This would seem to indicate that most divers in the accident database dive fairly often. There were, however, a large number of divers in whom the accident dive was the first dive for over a month. The majority of these accidents, though, were in more experienced divers.

## Figure 3.1 Primary Dive Activity

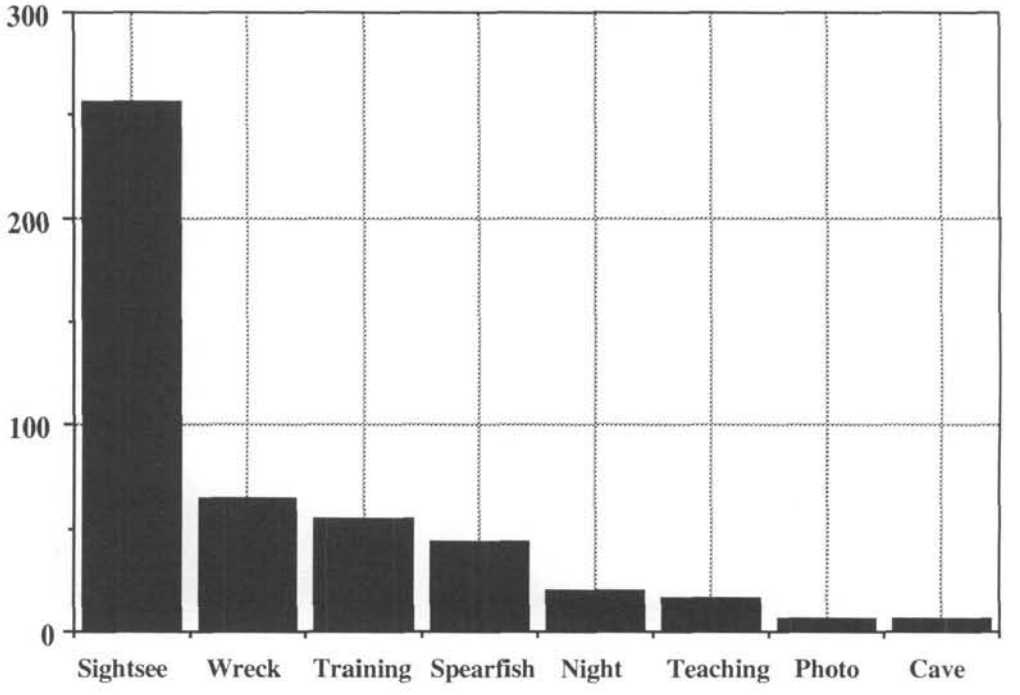
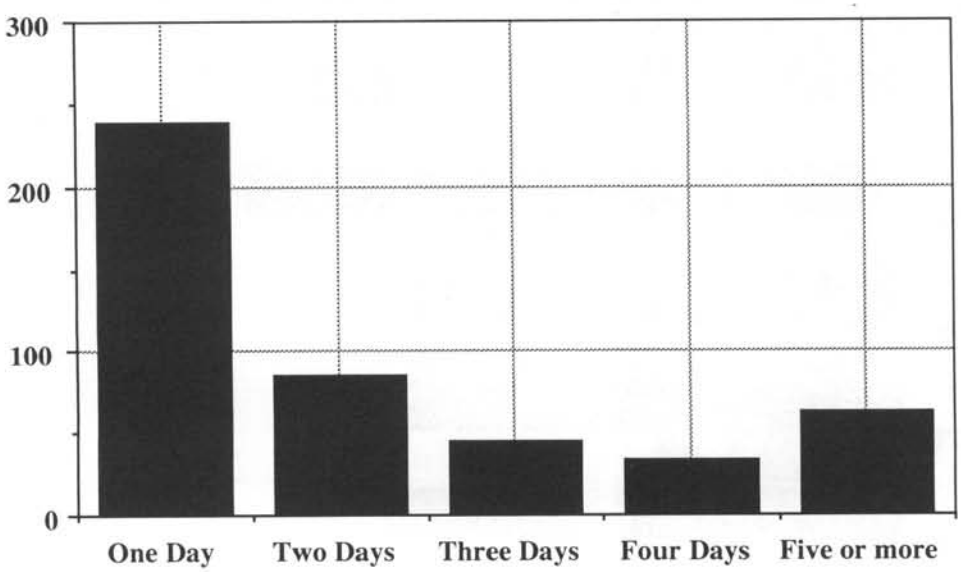


Figure 3.2 shows that just over half — 51 percent — of all divers in the database were injured on a single-day program. The remaining 49 percent were injured after two or more days of diving.

## Figure 3.2 Number of Days of Continuous Diving




## Dive Characteristics

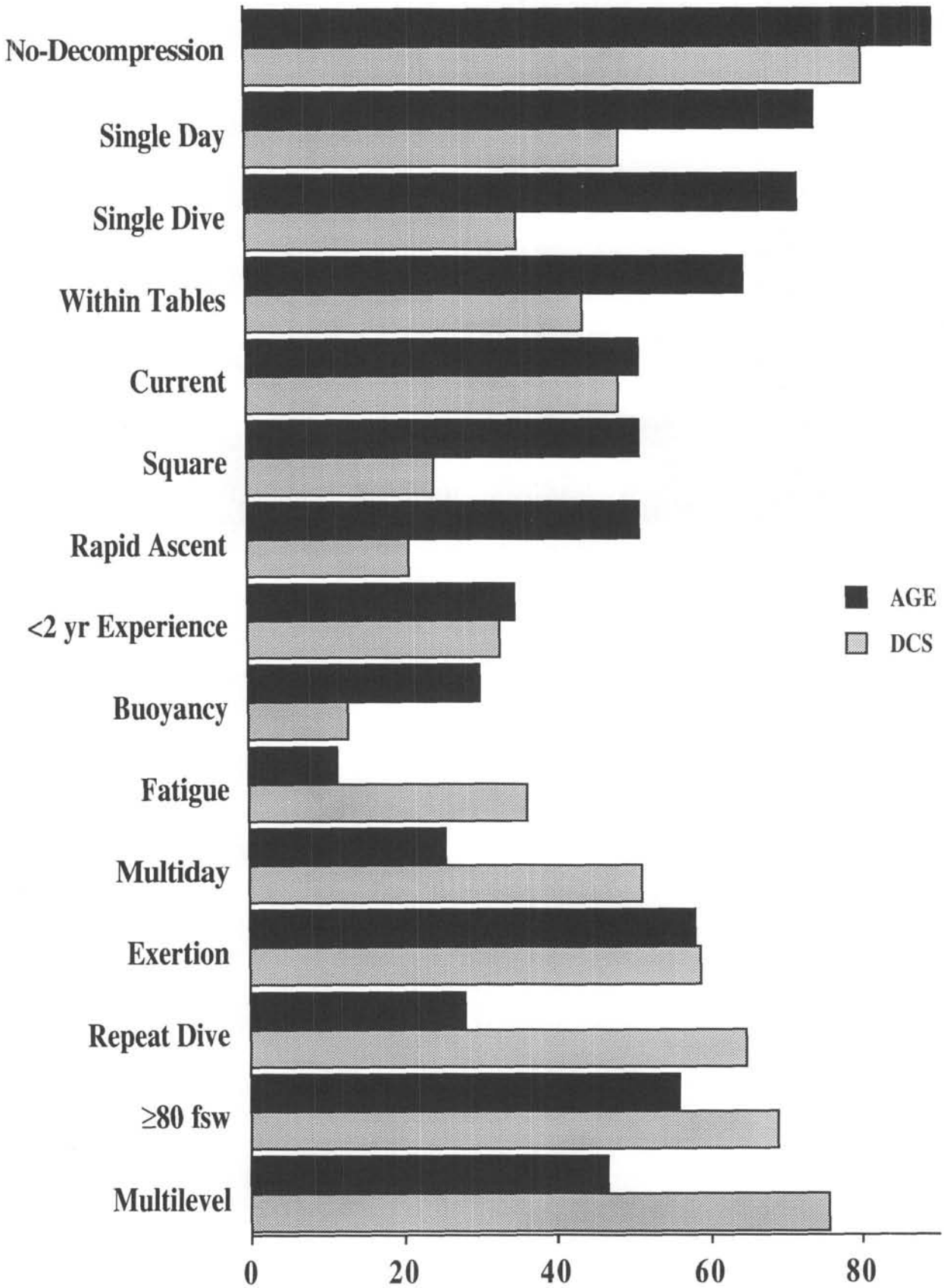
The characteristics of dives which resulted in both types of decompression illness — decompression sickness (DCS) and arterial gas embolism (AGE) — were similar (Figure 3.3).

Rapid ascent is a risk factor for gas embolism and probably also for decompression sickness. DCS usually results from the duration of exposure at a depth of around 30 feet or greater. Both conditions cause bubble formation, which can produce signs and symptoms in the individual affected.

The data of the two types of decompression illness are reported separately because the proposed mechanism of injury is different. The characteristics of the dives which produce each injury are similar, but the frequency of occurrence is different. There are many more reported cases of DCS (423 in 1992) than AGE (43 in 1992). The characteristics of each diagnosis from previous years are also presented to demonstrate yearly trends.

A typical AGE incident occurs with no-decompression shallow diving, within dive table limits, or during the first dive of the first day. Around 50 percent of divers claim to have made a rapid ascent,

## Figure 3.3 Percentage of DCS and AGE Dive Characteristics



which is usually recognized as being the predominant cause of AGE. The characteristics of dives which resulted in AGE have been consistent over the last five years. Figure 3.4 shows the comparative yearly data. Time and depth exposures are not considered to be a major contributing factor to AGE, and this is reflected in the characteristics presented here. Only 56 percent of divers went deeper than 80 feet, and 60 percent were within the no-decompression limits. However, the diagnoses AGE and DCS may in part have been assigned using dive profile information. Thus, the differences apparent in these data may be influenced by this.

A comparison of Figure 3.4 and 3.5 will show various dive characteristics in both AGE and DCS. For example, in 1992 a rapid ascent occurred in 51 percent of AGE cases but only in 21 percent of DCS cases. The characteristics of reported DCS cases are different from those who reported AGE. DCS was associated with deep dives (80 feet or greater), repetitive diving within the tables, and with multilevel profiles.

## Figure 3.4 Characteristics of Dives that Resulted in AGE

| Attribute | 1992 Percent | 1991 Percent | 1990 Percent | 1989 Percent | 1988 Percent |
|---|---|---|---|---|---|
| No-Decompression | 93.0 | 90.7 | 90.8 | 92.2 | 97.8 |
| Within Tables | 65.1 | 70.4 | 80.3 | 84.8 | 87.0 |
| Single Dive | 72.1 | 63.0 | 74.6 | 67.3 | 71.7 |
| Single Day | 74.4 | 64.8 | 66.7 | 53.8 | 69.6 |
| Square | 51.2 | 59.3 | 60.7 | 60.4 | 84.8 |
| Rapid Ascent | 51.2 | 59.3 | 57.1 | 55.8 | 54.3 |
| ≥ 80 fsw | 55.8 | 46.3 | 52.1 | 46.2 | 45.7 |
| Current | 51.2 | 48.1 | 40.0 | 40.4 | 30.4 |
| Multilevel | 46.5 | 40.7 | 39.3 | 39.6 | 15.2 |
| < 2 yr. Experience | 34.9 | 51.9 | 33.8 | 47.1 | 54.3 |
| Multiday | 25.6 | 35.2 | 33.3 | 46.2 | 30.4 |
| Repeat Dive | 27.9 | 37.0 | 25.4 | 32.7 | 28.3 |
| Buoyancy | 30.2 | 33.3 | 23.9 | 9.6 | 28.3 |
| Exertion | 58.1 | 53.7 | 22.5 | 15.7 | 21.7 |
| Fatigue | 11.6 | 16.7 | 11.3 | 25.5 | 28.3 |
| | *n* = 43 | *n* = 54 | *n* = 71 | *n* = 52 | *n* = 46 |

## Figure 3.5 Characteristics of Dives that Resulted in DCS

| Attribute | 1992 Percent | 1991 Percent | 1990 Percent | 1989 Percent | 1988 Percent |
|---|---|---|---|---|---|
| No-Decompression | 80.8 | 75.7 | 78.9 | 78.2 | 70.3 |
| Within Tables | 43.8 | 41.3 | 45.4 | 54.1 | 58.1 |
| Single Dive | 35.3 | 34.7 | 18.3 | 31.5 | 34.7 |
| Single Day | 48.8 | 53.0 | 52.9 | 50.6 | 48.2 |
| Square | 24.2 | 43.6 | 41.2 | 42.6 | 54.5 |
| Rapid Ascent | 21.1 | 22.2 | 22.4 | 25.3 | 23.9 |
| ≥ 80 fsw | 69.0 | 73.4 | 76.8 | 68.2 | 72.1 |
| Current | 48.6 | 53.0 | 49.7 | 42.1 | 39.2 |
| Multilevel | 75.6 | 56.4 | 54.6 | 52.1 | 45.5 |
| < 2 yr. Experience | 32.9 | 30.0 | 28.9 | 11.5 | 23.9 |
| Multiday | 51.2 | 47.0 | 47.1 | 49.4 | 51.8 |
| Repeat Dive | 64.7 | 65.0 | 81.7 | 68.5 | 65.3 |
| Buoyancy | 13.0 | 11.7 | 9.8 | 15.3 | 11.7 |
| Exertion | 58.8 | 62.7 | 24.7 | 29.4 | 24.8 |
| Fatigue | 36.3 | 36.0 | 30.2 | 32.9 | 32.4 |
| | *n* =422 | *n* = 383 | *n* = 388 | *n* = 339 | *n* 222 |

**When making multilevel dives, computer users may ... go deeper during their repetitive dives using the computer algorithm for guidance.**

## Dive Computer Use

The dive computer credits the diver for spending time at shallow depths and assumes that nitrogen offgassing occurs at that time. Typically, this means that computer users can extent their dive time longer than table users and shorten their surface intervals. When making multilevel dives, computer users have the option of going deeper during their repetitive dives using the computer algorithm for guidance. In 1992 slightly less than 50 percent of divers with a decompression illness in this report were using computers on their dive. The incidence of a neurological decompression illness in both computer dives and table divers was approximately equal. However, 22 percent of computer divers had pain-only DCS, while only 13 percent of table divers suffered a similar illness.

In 1992, the trend in the percentage and number of divers using tables and who suffered AGE remained the same as in previous

years. Arterial gas embolism was approximately two or three times greater in frequency in table users than computer users. Computer users in the DAN database were more experienced divers who have been diving both more often and for a greater number of years than table users. This may indicate that table users were more likely to miscalculate time and run out of air. The fact that nearly three-quarters of all injured divers who suffered decompression illness had neurological signs is of importance.

## Figure 3.6 Decompression Illness in Computer and Table Divers

| | Computer Users | | | | | |
|---|---|---|---|---|---|---|
| | 1992 Percent | 1991 Percent | 1990 Percent | 1989 Percent | 1988 Percent | 1987 Percent |
| DCS I | 22.3 | 20.1 | 28.1 | 31.0 | 31.0 | 26.8 |
| DCS II | 71.4 | 73.4 | 64.0 | 62.7 | 60.7 | 61.0 |
| AGE | 6.3 (14) | 6.5 (13) | 7.9 (16) | 6.3 (8) | 8.3 (7) | 12.2 (5) |
| TOTAL | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |
| | *n* = 224 | *n* = 199 | *n* = 203 | *n* = 126 | *n* = 84 | *n* = 41 |

| | Table Users | | | | | |
|---|---|---|---|---|---|---|
| | 1992 Percent | 1991 Percent | 1990 Percent | 1989 Percent | 1988 Percent | 1987 Percent |
| DCS I | 12.9 | 16.0 | 17.2 | 18.5 | 18.5 | 15.8 |
| DCS II | 75.1 | 66.8 | 61.3 | 64.9 | 60.3 | 63.6 |
| AGE | 12.0 (29) | 17.2 (41) | 21.5 55 | 16.6 42 | 21.2 (39) | 20.6 |
| TOTAL | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** (47) |
| | *n* = 241 465 | *n* = 238 437 | *n* = 256 459 | *n* = 256 382 | *n* = 184 268 | *n* = 228 269 |

Comparison of the trends in those divers who have used standard decompression tables or dive computers can be made using Figure 3.7 and 3.8. The use of computers supposedly enables divers to make repetitive dives more safely. However, while using computers, over 80 percent of the divers suffering decompression illness in 1992 made multilevel repetitive dives at depths greater than 80 feet. Other factors may have contributed to this difference, such as rate-of-ascent alarms in decompression computers. Only 22 percent of table-user accidents felt they were outside standard tables (see Figures 3.7 and 3.8), whereas nearly 40 percent of computer users stated a similar occurrence. Formal staged decompression has further decreased recently in computer users, presumably as the computer indicates there is no need for decompression at the end of the dive schedule.

## Figure 3.7 Attributes of Computer Divers From 1987-1992

| Attribute | 1992 Percent | 1991 Percent | 1990 Percent | 1989 Percent | 1988 Percent | 1987 Percent |
|---|---|---|---|---|---|---|
| Repeat Dive | 84.4 | 87.4 | 82.3 | 73.0 | 80.5 | 73.2 |
| Fatigue | 35.9 | — | — | — | — | — |
| Within Tables | 60.3 | 24.6 | 27.6 | 26.2 | 44.0 | 29.3 |
| ≥ 80 fsw | 77.7 | 80.4 | 85.7 | 81.0 | 82.0 | 92.7 |
| Single Day | 47.8 | 54.3 | 51.7 | 48.4 | 45.5 | 48.3 |
| Current | 47.3 | 47.2 | 52.2 | 44.4 | 42.9 | 43.9 |
| Multi Day | 52.2 | 45.7 | 47.8 | 51.6 | 54.5 | 51.7 |
| Multilevel | 91.1 | 80.4 | 67.5 | 68.3 | 58.4 | 56.1 |
| Exertion | 58.1 | 56.8 | 29.6 | 31.0 | 26.2 | 34.1 |
| Outside Tables | 39.7 | — | — | — | — | — |
| Decompression | 25.9 | 25.1 | 27.1 | 20.6 | 36.9 | 48.8 |
| | $n = 224$ | $n = 199$ | $n = 203$ | $n = 126$ | $n = 84$ | $n = 41$ |

## Figure 3.8 Attributes of Table Divers From 1987-1992

| Attribute | 1992 Percent | 1991 Percent | 1990 Percent | 1989 Percent | 1988 Percent | 1987 Percent |
|---|---|---|---|---|---|---|
| Repeat Dive | 73.4 | 71.0 | 70.3 | 58.5 | 57.0 | 52.4 |
| Fatigue | 32.4 | — | — | — | — | — |
| Within Tables | 68.9 | 61.8 | 69.1 | 71.7 | 71.7 | 68.1 |
| ≥ 80 fsw | 58.5 | 61.3 | 62.9 | 38.5 | 69.0 | 60.3 |
| Single Day | 54.4 | 54.6 | 54.3 | 51.7 | 52.0 | 49.7 |
| Current | 50.2 | 56.7 | 44.9 | 40.8 | 35.3 | 37.9 |
| Multi Day | 45.6 | 45.4 | 43.8 | 48.3 | 47.6 | 50.3 |
| Multilevel | 60.2 | 36.6 | 39.5 | 40.8 | 38.6 | 19.7 |
| Exertion | 59.8 | 65.5 | 23.4 | 26.0 | 23.4 | 32.3 |
| Outside Tables | 21.6 | — | 23.0 | 25.7 | 28.3 | 31.9 |
| Decompression | 13.7 | 18.1 | 12.1 | 16.2 | 19.6 | 21.8 |
| | $n = 241$ | $n = 238$ | $n = 256$ | $n = 265$ | $n = 184$ | $n = 229$ |

## Equipment

Scuba diving is an activity that requires knowledge of the equipment used, as well as adequate maintenance. The correct functioning of the equipment and the knowledge of its use are essential to diver safety. Sixteen and a half percent of the 1992 cases in this report involved equipment problems. This low number of equipment problems has remained fairly stable.

The fact that equipment problems were reported does not necessarily mean that the equipment failed or malfunctioned. Unfamiliarity with the equipment is also a possible cause for making a report. These problems could have been a contributing factor to the development of decompression illness and, in the cases of divers suffering AGE, may have indeed caused the injury. The number of divers reporting equipment problems with AGE, however, was so low that no real conclusions can be drawn from the data.

Those divers with DCS who reported an equipment problem were equally likely to have had a problem with their regulator, dive computer, or buoyancy control.

**Sixteen and a half percent of the 1992 cases in this report involved equipment problems ...**

**The fact that equipment problems were reported does not necessarily mean that the equipment failed or malfunctioned. Unfamiliarity with the equipment is also a possible cause for a report to be made.**

### Figure 3.9 1992 Equipment Problems

| Equipment | Frequency | DCS | AGE |
|---|---|---|---|
| Regulator | 16 | 10 | 6 |
| BC Vest | 7 | 4 | 3 |
| Weight Belt | 4 | 3 | 1 |
| Dry Suit | 7 | 7 | 0 |
| DC Computer | 8 | 8 | 0 |
| Inflator Hose | 4 | 4 | 0 |
| Contaminated Air | 1 | 1 | 0 |
| Unfamiliar Equipment | 12 | 8 | 4 |
| Other | 18 | 14 | 4 |
| **TOTALS** | **77** | **59** | **18** |

# Symptoms

The most frequent symptoms of decompression illness reported are shown in Figure 4.1. Symptoms which were suggestive of neurological or cardiorespiratory involvement have been noted with an asterisk. Symptoms shown in bold have been arbitrarily classified as the most severe neurological symptoms. In this latter group, weakness and hearing loss were not included because of some degree of ambiguity (i.e., generalized weakness, indicating fatigue versus true motor weakness; hearing loss due to otic barotrauma versus neurological injury). A total of 381 of the 465 cases (82 percent) developed neurological or cardiorespiratory symptoms. Some 119 cases (26 percent) developed the most severe neurological symptoms (shown in bold).

**One of the differences between recreational divers and other types of divers has been a preponderance of neurological symptoms versus only a small percentage traditionally reported in commercial or military divers.**

One of the differences between recreational divers and other types of divers has been a preponderance of neurological symptoms versus only a small percentage traditionally reported in commercial or military divers. One of the reasons suggested is that commercial and military divers are usually treated quickly after the onset of symptoms (on-site chamber), preventing the onset of neurological symptoms which might otherwise occur in untreated divers. Support for this hypothesis is provided in Figure 4.1. Although 82 percent of the cases ultimately had neurological symptoms, only 166 cases (36 percent) had a neurological first symptom. Recent data from the U.S. Navy suggest that there may be no differences between the types of decompression illness reported in the two populations. From 1991-93, neurological decompression illness was more common than pain-only bends.

Other possibilities include a reluctance to admit neurological symptoms on the part of professional divers. Age differences in the two populations have also been implicated in the preponderance of neurological symptoms in recreational divers. However, 70 percent of dive accident victims in the DAN population are between the ages of 20 and 39 — very similar to the commercial and military population. It has also been suggested that recreational divers may be less fit than professional divers. In the DAN questionnaire, around 90 percent of accident victims state that they are physically fit, though this is not quantified.

# 1992 Most Frequent Symptoms of Decompression Illness

| Symptom | First Symptom | | Total Occurrence | |
|---|---|---|---|---|
| | Frequency | Percent | Frequency | Percent |
| Pain | 184 | 39.6 | 282 | 60.6 |
| Numbness* | 84 | 18.1 | 261 | 56.1 |
| Dizziness* | 37 | 8.0 | 111 | 23.8 |
| Headache | 33 | 7.1 | 99 | 21.2 |
| Extreme Fatigue | 30 | 6.5 | 106 | 22.8 |
| Nausea | 21 | 4.5 | 73 | 15.6 |
| Weakness* | 16 | 3.4 | 103 | 22.2 |
| Itching | 11 | 2.4 | 40 | 8.6 |
| Other | 10 | 2.2 | 37 | 7.9 |
| Difficulty Breathing* | 8 | 1.7 | 31 | 6.6 |
| Rash | 6 | 1.3 | 17 | 3.6 |
| Personality Change* | 5 | 1.1 | 30 | 6.5 |
| **Unconscious*** | 5 | 1.1 | 22 | 4.7 |
| **Visual Disturbance*** | 4 | 0.9 | 54 | 11.6 |
| **Semi-Conscious*** | 3 | 0.6 | 18 | 3.9 |
| Muscle twitch | 2 | 0.4 | 18 | 3.9 |
| **Difficulty Walking*** | 2 | 0.4 | 51 | 11.0 |
| Restless | 2 | 0.4 | 21 | 4.5 |
| **Bladder Problem*** | 1 | 0.2 | 15 | 3.2 |
| **Bowel Problem*** | 1 | 0.2 | 7 | 1.5 |
| **Paralysis*** | 0 | 0.0 | 25 | 5.4 |
| Ringing Ears | 0 | 0.0 | 9 | 1.9 |
| Hearing Loss | 0 | 0.0 | 2 | 0.4 |
| **Speech Disturbance*** | 0 | 0.0 | 14 | 3.0 |
| Reflex Change* | 0 | 0.0 | 9 | 1.9 |
| Hemoptysis | 0 | 0.0 | 3 | 0.6 |
| **Convulsion*** | 0 | 0.0 | 4 | 0.8 |
| Decreased Skin Sensation* | 0 | 0.0 | 34 | 7.3 |
| **TOTALS** | **465** | **100.1** | | |

* *Symptoms which were suggestive of neurological or cardiorespiratory involvement have been noted with an asterisk.*
*Symptoms shown in* ***bold*** *have been arbitrarily classified as the most severe neurological symptoms.*

**... 56 percent of the DAN accident reports indicate that the divers were outside the tables ...**

Finally, there may be differences in patterns of diving. Indeed, 56 percent of the DAN accident reports indicate that the divers were outside the tables; 21 percent reported a rapid ascent; and 13 percent reported buoyancy problems. These factors which are less likely to be present in professional divers.

Figure 4.2 shows that the majority of divers were diagnosed with DCS type II. The difference between the 73.3 percent DCS II shown in Figure 4.2 and the 82 percent by our own analysis (see text, page 40) may reflect the lack of reporting of some symptoms by divers to their treating physician or inconsistent application of the classification. Interestingly, the percentage of divers with air embolism has decreased over the years. This may possibly reflect better training and avoidance of rapid ascent or breath-holding. It may also reflect differing dive patterns or merely an increase in the numbers of non-AGE injuries.

## Figure 4.2 Conventional Disease Diagnosis

| Final Diagnosis | 1992 Percent | 1991 Percent | 1990 Percent | 1989 Percent | 1988 Percent | 1987 Percent |
|---|---|---|---|---|---|---|
| DCS I | 17.4 | 17.8 | 22.0 | 22.5 | 22.4 | 17.4 |
| DCS II | 73.3 | 69.8 | 62.5 | 64.5 | 60.4 | 63.3 |
| Air Embolism | 9.2 | 12.4 | 15.5 | 13.0 | 17.2 | 19.3 |
| **TOTAL** | **99.9** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |
| | n = 465 | n = 437 | n = 459 | *n* = 391 | *n* = 268 | *n* = 270 |

Figure 4.3 shows that approximately 20 percent of divers with decompression illness developed symptoms prior to the last dive. Why divers should continue to dive with symptoms of decompression illness is not certain. Possibly it reflects lack of knowledge about decompression symptoms.

## Figure 4.3 Decompression Illness Symptoms Prior to Last Dive

| Sex | 1992 Percent | 1991 Percent | 1990 Percent | 1989 Percent | 1988 Percent |
|---|---|---|---|---|---|
| Male | 20.1 | 16.8 | 13.9 | 12.4 | 14.8 |
| Female | 22.1 | 24.5 | 19.0 | 25.3 | 26.6 |
| **TOTAL** | **20.7** | **18.8** | **15.2** | **15.7** | **17.5** |
| | *n* = 465 | *n* = 437 | *n* = 459 | *n* = 381 | *n* = 268 |

Figure 4.4 shows that around 8 to 10 percent of divers who reported decompression illness in 1992 had experienced previous episodes. Of those with no previous decompression illness, the mean number of lifetime dives reported was 325 (median 60). Those with previous episodes of decompression illness reported a mean number of total lifetime dives of 3421 (median 155). These figures are suggestive (though not conclusive) that individuals who suffer multiple episodes of decompression sickness may be a select group with particular risk factors.

**... individuals who suffer multiple episodes of decompression sickness may be a select group with particular risk factors.**

## Figure 4.4 Percentage of Divers Who Suffered Previous Decompression Illness

| Sex | 1992 | 1991 | 1990 | 1989 | 1988 |
|---|---|---|---|---|---|
| Male | 10.33% | 15.9% | 12.7% | 15.1% | 12.4% |
| Female | 4.4% | 3.6% | 10.7% | 11.8% | 8.6% |
| Total Population | 8.6% | 12.8% | 12.2% | 14.1% | 11.6% |
| | *n*=465 | *n*=436 | *n*=459 | *n*=391 | *n*=268 |

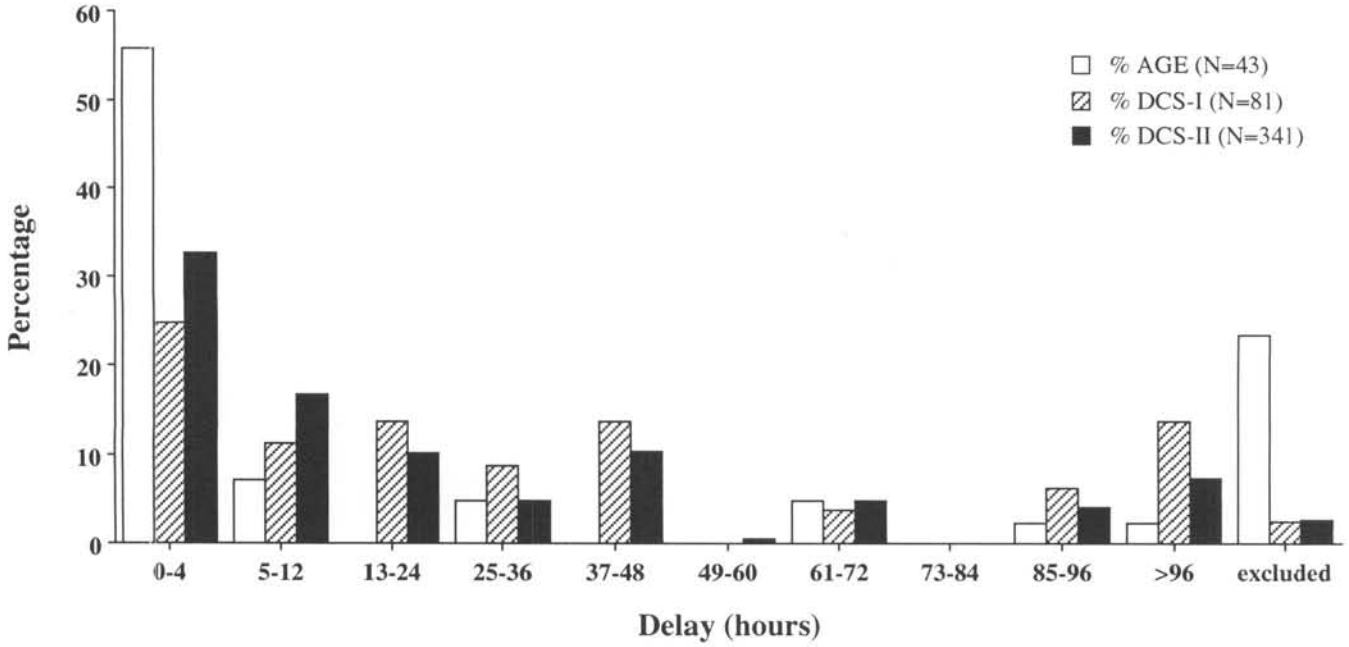
# Treatment

**Additionally, long delays in requests for assistance continued to be noted for all types of DCI.**

Prompt diagnosis and appropriate treatment of decompression illness is an important factor in the outcome of the injured diver. The following data represents a summary of the treatment information received by DAN for diving accidents in 1992.

Figure 5.1 shows that nearly 50 percent of all AGE cases reported to DAN requested assistance in less than four hours of presentation of symptoms. Considerable delay and variability in time from symptom onset to the time of request for medical assistance is noted in the data for DCS. Only 25 percent to 30 percent of all DCS cases reported to DAN requested assistance in the first four hours following symptom onset. Additionally, long delays in requests for assistance continued to be noted for all types of DCI.

## Figure 5.1 Delay From Onset of Symptoms to Calling for Assistance



Sixty-nine percent of all reported DCI cases initially contacted either DAN, an M.D., or a local hospital emergency department for assistance (Figure 5.2). The "other" category includes contacts as to divemasters, hyperbaric chamber staff, dive club management, highway patrol, certifying agencies, friends, or dive buddies.

## Figure 5.2 First Contact for Assistance

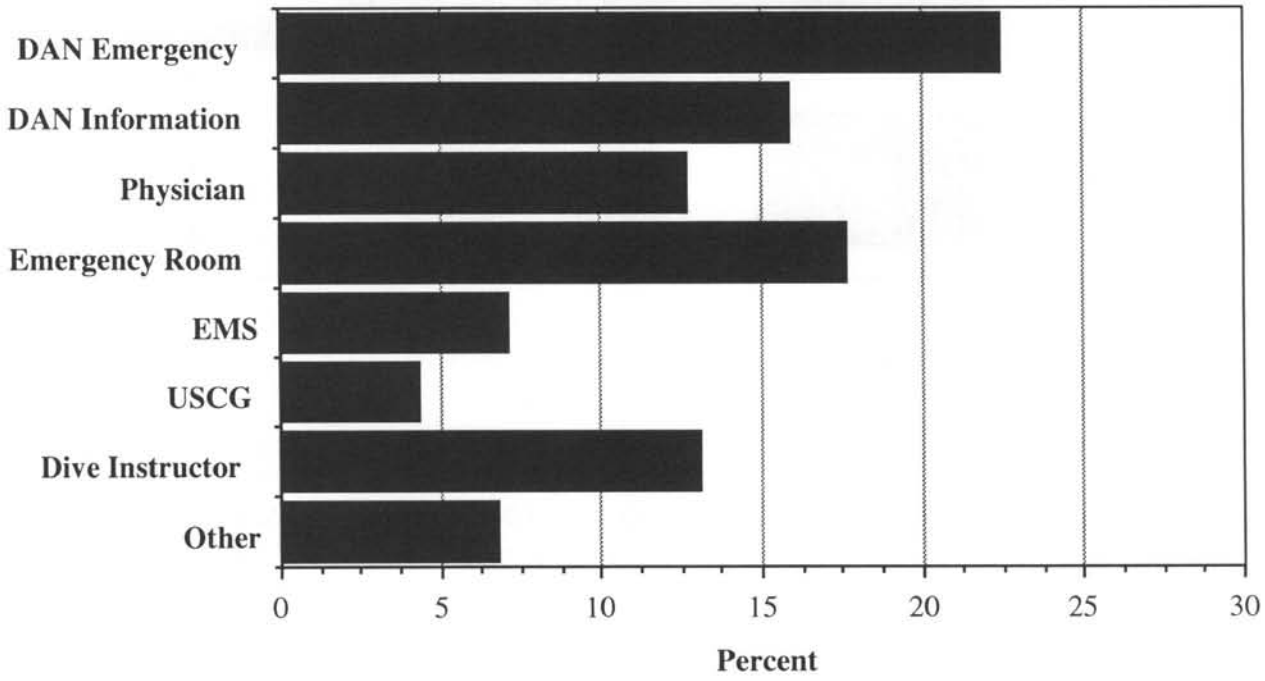
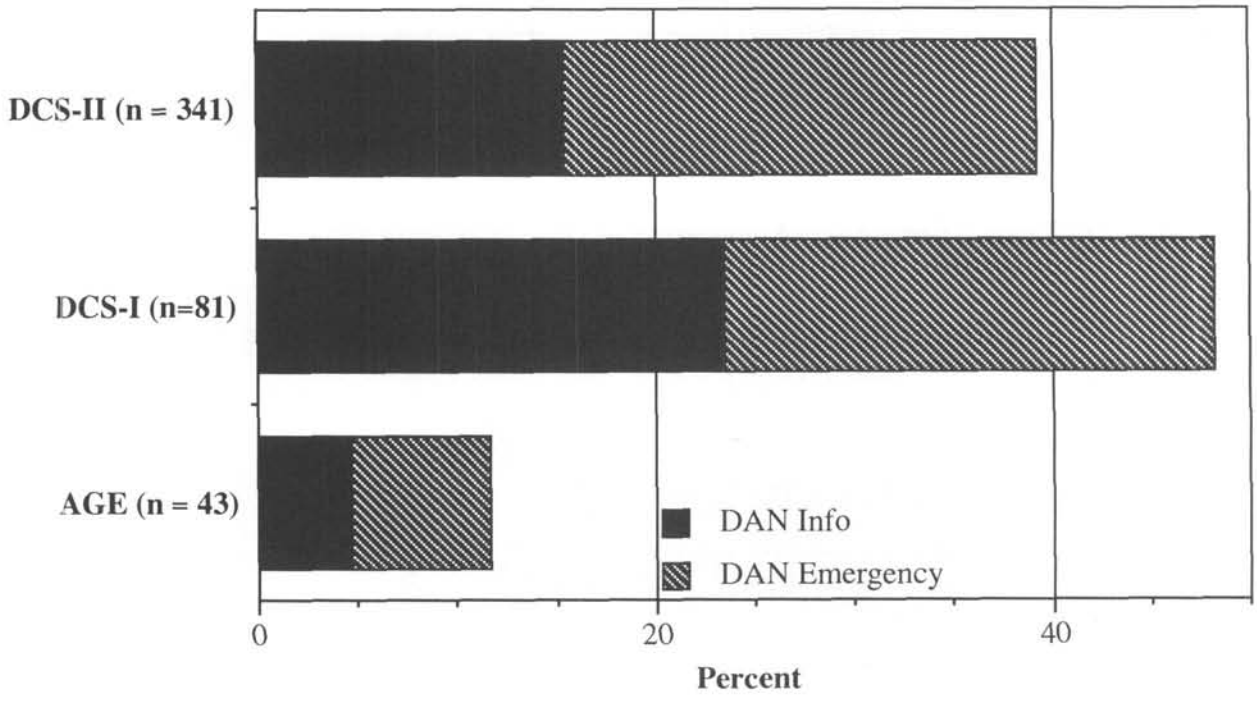



Figure 5.3 shows that nearly half of the 178 initial calls to DAN were made concerning DCS-I symptoms. Half of these came in through the emergency number and the other half through the regular information line. Only 40 percent of the DCI phone calls to DAN were related to DCS-II symptoms. In spite of the importance of prompt medical treatment in neuological DCS (Type II), 37 percent of these calls were made through the information line and not the emergency number. Very few emergency AGE cases utilized DAN as the initial contact for assistance. This may be due to the immediate nature of AGE symptoms.

**In spite of the importance of prompt medical treatment in neuological DCS, 37 percent of these calls were made through the information line and not the emergency number.**

## Figure 5.3 Intial Call to DAN by DCI Type

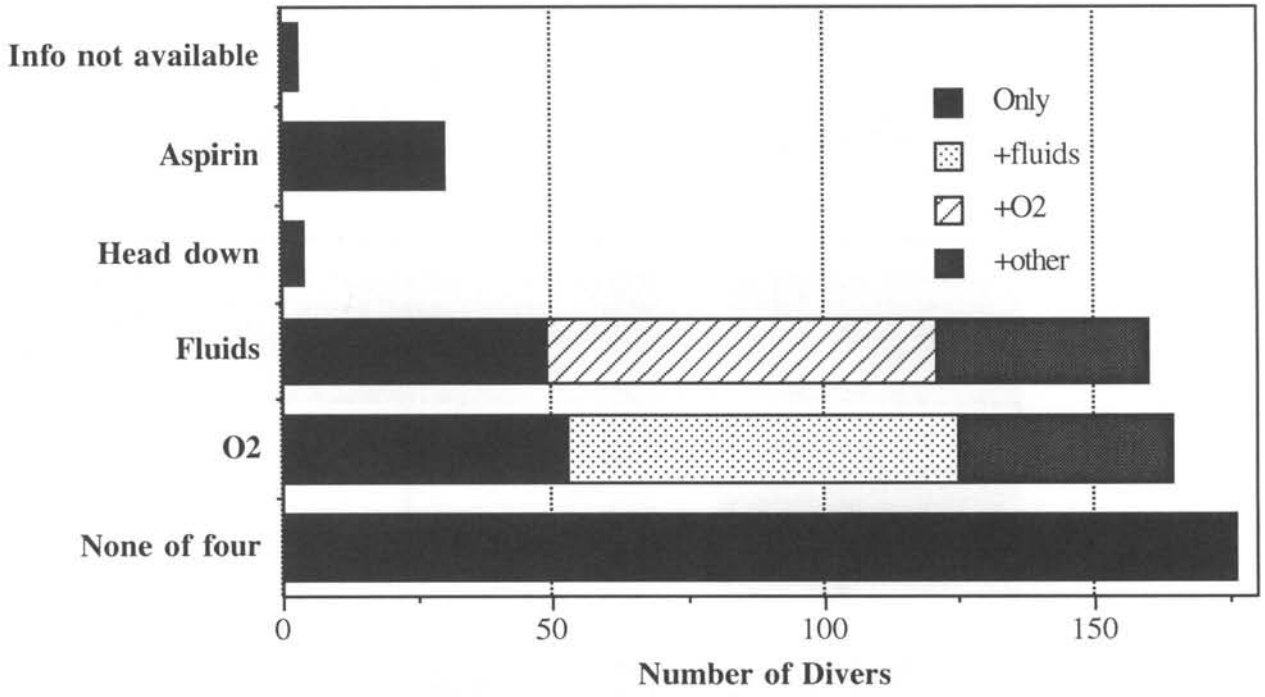



**The time delay from onset of symptoms to beginning recompression therapy is variable**

Thirty-five percent of DCI cases reported to DAN used oxygen alone or in combination with other treatments (not including fluid) for first aid (Figure 5.4). Thirty-four percent used fluid alone or in combination with other interventions (not including oxygen). Seventy-two of the 465 DCI cases used both fluids and oxygen as first aid (15 percent). One hundred seventy-six of the 465 DCI cases (38 percent) in the DAN database did not utilize either oxygen or fluids.

The time delay from onset of symptoms to beginning recompression therapy is variable (Figure 5.5). Forty five-percent of AGE cases reported to DAN receive hyperbaric therapy within four hours of symptom onset, and nearly 75 percent of the AGE cases were treated within the first 12 hours. Delay to treatment for DCS Type I and II was greater, with only 32 percent and 37 percent respectively being treated within the first 12 hours of symptom onset. The causes of the delay to treatment are numerous and include denial of symptoms, failure to correlate symptoms with DCI, and remote dive locations with subsequent difficulty in evacuation.

## Figure 5.4 First Aid Used




## Figure 5.5 Delay from Symptom Onset to Recompression Therapy

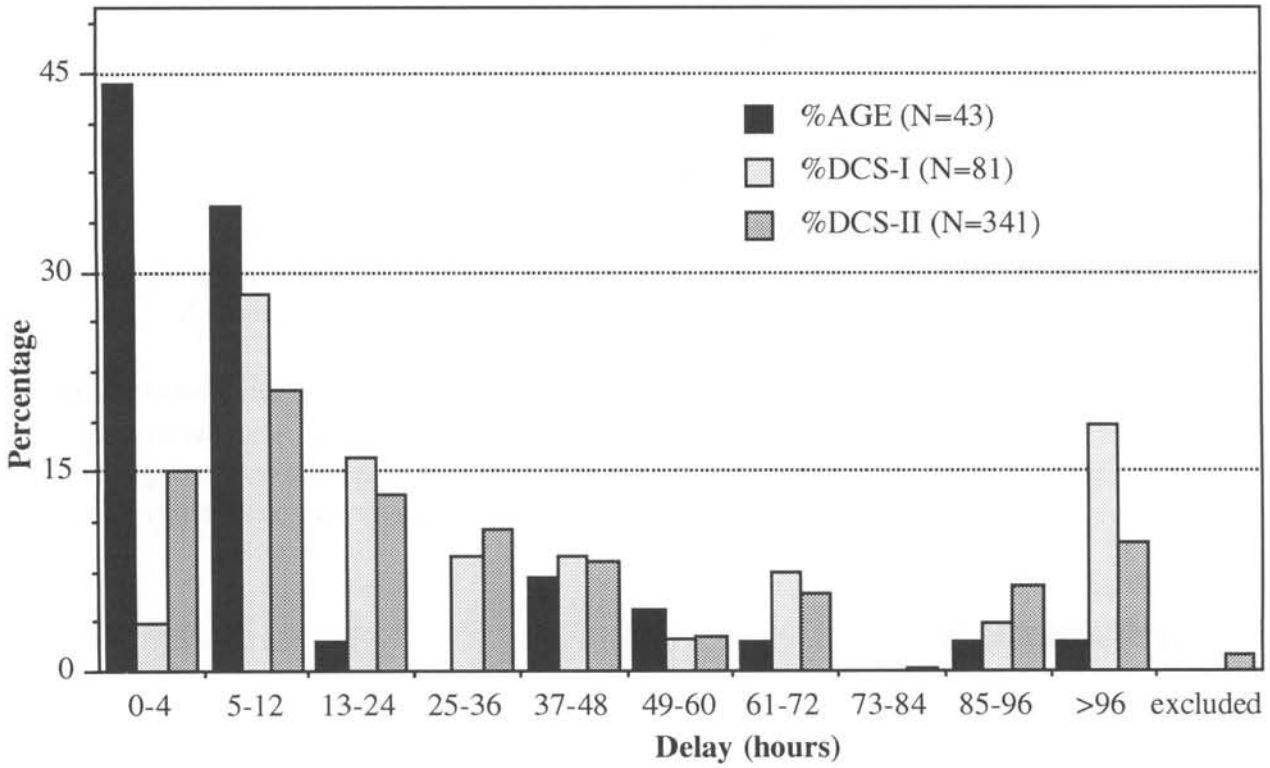
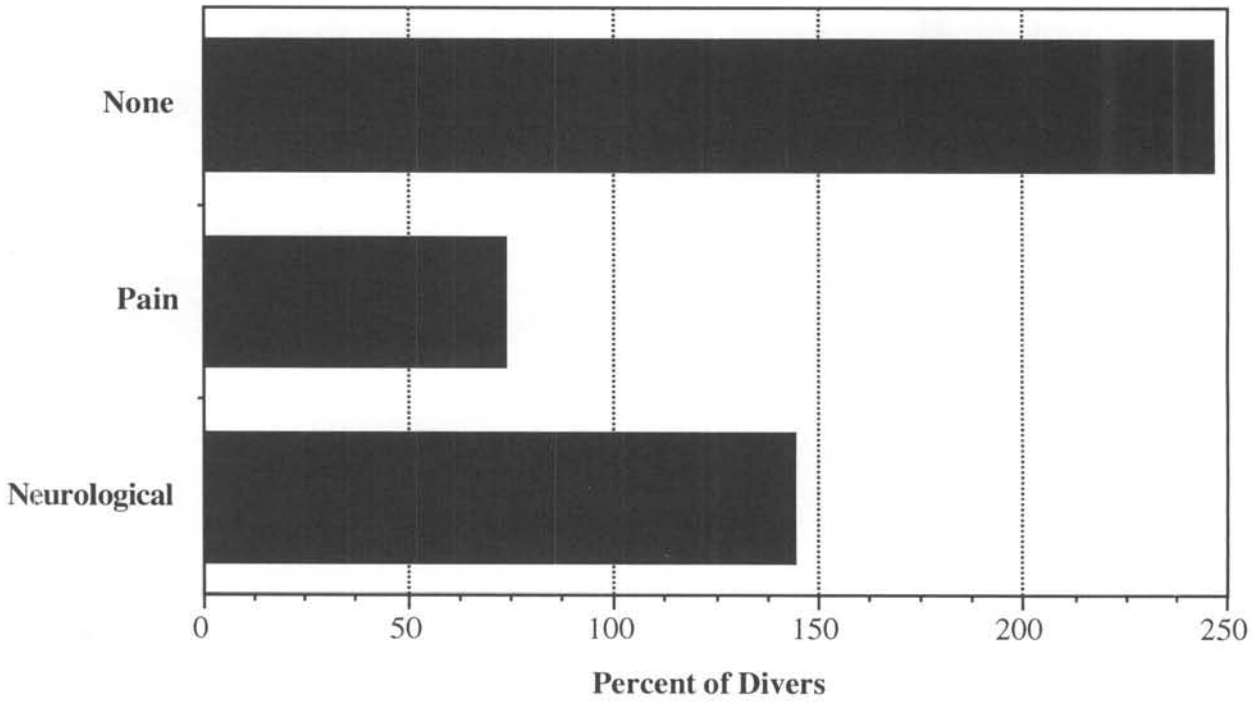


Figure 5.6 shows that hyperbaric oxygen therapy for DCI cases reported to DAN indicates that more than 50 percent of the cases were treated successfully without residual symptoms remaining after treatment.

## Figure 5.6 Post-Treatment Residuals

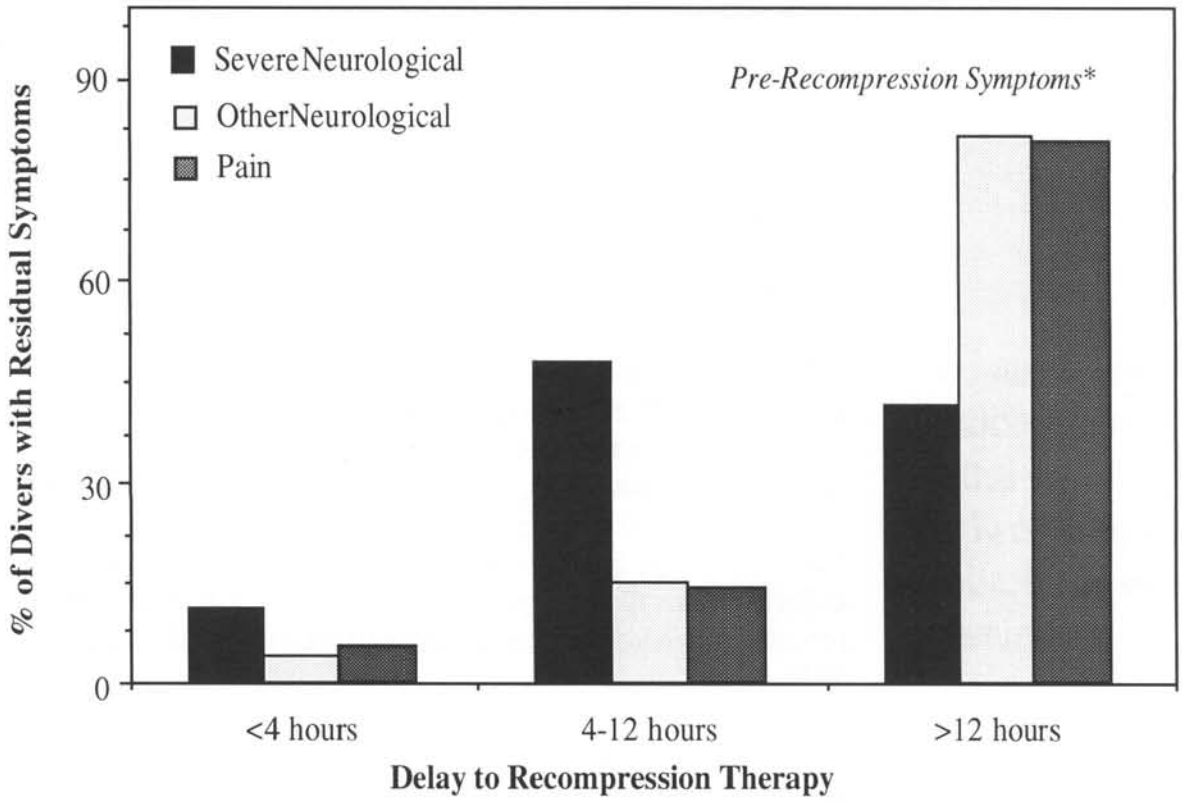



**The ability to reduce the severity of symptoms or to totally resolve the symptoms with recompression is directly correlated with the promptness with which hyperbaric therapy is started.**

The ability to reduce the severity of symptoms or to totally resolve the symptoms with recompression is directly correlated with the promptness with which hyperbaric therapy is started. Increasing delays result in incomplete resolution of symptoms for all types and severity of DCI. These results are shown in Figure 5.7.

One can only speculate that mild or confusing symptoms may delay the reporting of DCI symptoms by the diver. Also, the onset of symptoms occurring away from the dive site where diving is the center of attention and experienced divers are present may lessen the

## Figure 5.7 Percent Divers with Post-Recompression Residual Symptoms as a Function of Pre-Recompression Symptoms and Delay to Recompression Therapy




* The pre-hyperbaric symptoms were categorized according to severe neurological symptoms, other neurological symptoms, and pain using the criteria established in Figure 4.1.

attention given to DCI symptoms. The curious finding that initial calls for assistance occurred two days after symptom onset and correlated with the end of a weekend is suspiciously coincidental. Both increased education of each diver as well as the education of the initial responder is essential to rapid recognition and diagnosis of decompression illness.

**Increasing delays result in incomplete resolution of symptoms for all types and severity of DCI.**

# Scuba Fatalities — Introduction

**The total number of individuals who are active scuba divers but have no certification is unknown.**

Recreational scuba fatalities have been reported since 1970. The original collection reporting effort was done by the National Underwater Accident Data Center (NUADC) at the University of Rhode Island. Since 1990 NUADC has been part of the effort to collect fatalities with the Divers Alert Network. In the last 23 years, a total of 2,404 U.S. recreational scuba fatalities have been recorded. Figure 6.1 shows the number of yearly fatalities has varied, from a high of 147 to a low of 66, giving a range of 81 deaths. The average over this time period has been approximately 104 deaths per year. The high average is primarily due to the first 10 years of fatality collection when the average was 123 deaths per year. Half of all recorded recreational scuba fatalities occurred from 1970 through 1979.

The 1992 report on scuba fatalities is based primarily on deaths among U.S. residents while scuba diving. Two non-U.S. residents are included in this report because they died while diving in U.S. waters. Scuba diving deaths among individuals involved in professional, commercial (i.e. oil field), or occupational diving (i.e. self-employed, marine life harvester) are not counted in the recreational section. Appendix G contains information on occupational diving fatalities. Finally, fatalities among divers who were never trained or certified must also be included in the total number of yearly scuba fatalities. The total number of individuals who are active scuba divers and have no certification is unknown.

Each year an attempt is made to estimate the fatality rate per 100,000 active divers. The exact rate cannot be determined. This is largely due to the inability to obtain the number of active divers. Even if the exact number of new divers who enter scuba each year were known, there is still no way to track divers who drop out of scuba or remain active. Additionally, divers may re-enter the active diver population any year after certification. For this reason, it is not possible to determine or estimate a fatality rate. There were 29 more fatalities in 1992 than in 1991.

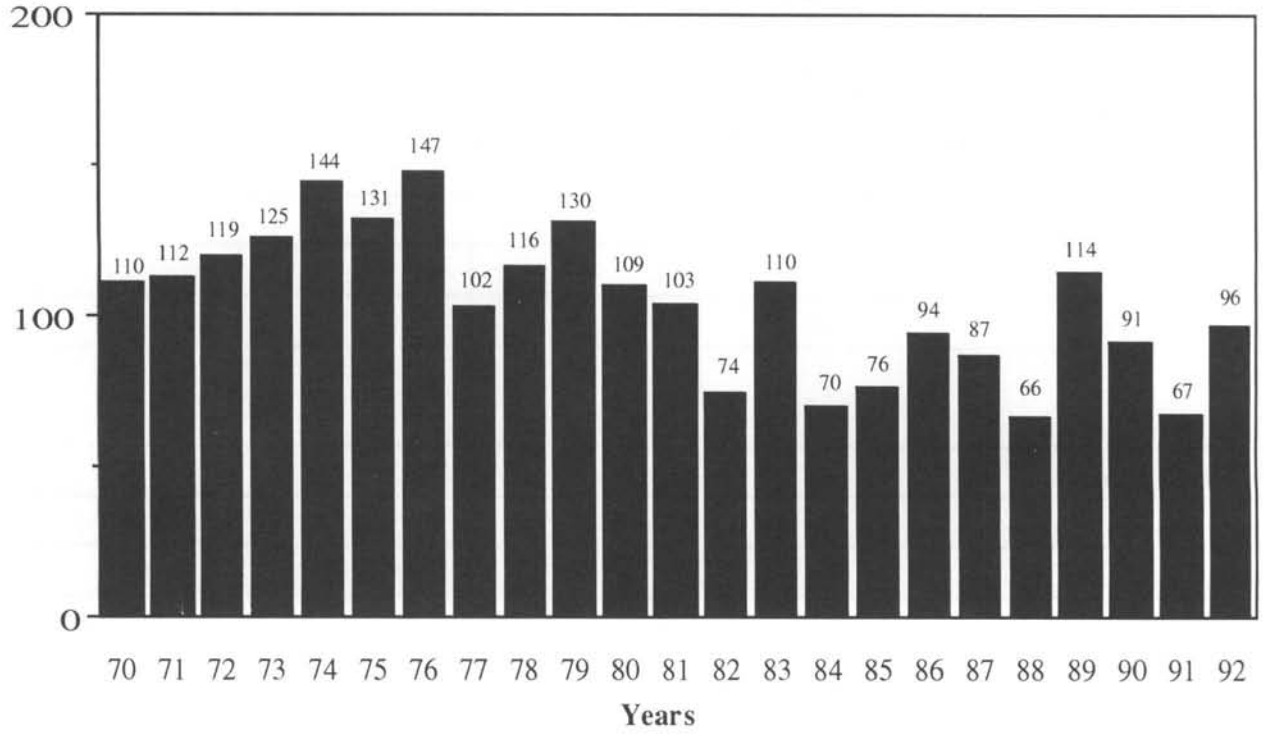
## Preliminary Report on 1993 Recreational Fatalities

As of December 17, 1993, there have been 90 recreational scuba fatalities reported to DAN for 1993. In all likelihood, additional fatalities will be reported increasing this yearly total. Sixty-four percent (54 deaths) have occurred since the first of July. Forty-eight percent (44 cases) occurred in June (four cases), July (13 cases), August (13 cases), and September (12 cases). There were nine female deaths, which represent only 10 percent of the total fatality population. This is the lowest percentage of female deaths reported since 1989. The number of uncertified divers in the population has not yet been established.

**As of December 17, 1993, there have been 90 recreational scuba fatalities reported to DAN for 1993.**

Florida has the highest number of reported deaths — 29 for 1993 — which increased from 22 in 1992. Nine deaths involved cave divers, with most of them being certified for this activity. There were five double fatalities in 1993, involving the following: two incidents with cave divers; one incident with ice diving; one buddy team both of whom were inexperienced and infrequent divers; and one incident between an instructor and student diver.

## Figure 6.1 Yearly U.S. Recreational Diving Fatalities



# Methods of Fatality Data Collection

**The DAN network of hyperbaric chamber personnel, emergency line assistance calls, or callers on the DAN information line, and other membership services account for the majority of contacts.**

Figure 7.1 shows the agencies and services that supply initial contact information regarding recreational scuba fatalities. Reports of fatalities are usually received by telephone contact. The DAN network of hyperbaric chamber personnel, emergency line assistance calls, or callers on the DAN information line, and other membership services account for the majority of contacts. About 40 percent of fatality contacts come into the DAN network. News clipping subscription services (Luce, Burrelle, CompuServe) are the second most common source of information. DAN is also contacted through various legal agencies or agencies which have an investigative interest in scuba fatalities. Medical examiners or coroners may call, as well as direct calls from newspapers that are seeking additional information regarding scuba fatalities in general. The other category of contacts refers to individuals who may have a relationship with DAN but no direct interest or involvement with scuba diving or diving fatalities.

## Figure 7.1 Intial Contacts

| | Inside United States | Outside United States | Total | Percentage |
|---|---|---|---|---|
| Dan Network | 29 | 9 | 38 | 39.6 |
| Subscription Services | 24 | 3 | 27 | 28.1 |
| Non Member | 7 | 2 | 9 | 9.4 |
| Legal/Agency | 1 | 0 | 1 | 1.0 |
| Investigative* | 9 | 1 | 10 | 10.4 |
| Medical Examiner/Coroner | 5 | 0 | 5 | 5.2 |
| Newspaper Direct | 3 | 0 | 3 | 3.1 |
| Other | 3 | 0 | 3 | 3.1 |
| **Total** | **81** | **15** | **96** | **99.9** |

**Police, Sheriff, and USCG*

Certain medical examiners, sheriff and police departments, U.S. Coast Guard, and other reporting agencies receive a quarterly mailing from DAN concerning diving safety and current medical issues in scuba diving. Since scuba fatalities are relatively rare, many agencies who deal with fatality investigation are unfamiliar with scuba diving. DAN offers investigators and medical examiners information regarding investigation and autopsy protocols. In this manner, DAN can assist in proper investigation. However, DAN is not an investigative agency.

**DAN offers investigators and medical examiners information regarding investigation and autopsy protocols.**

Figure 7.2 shows the primary sources of information used in the analysis of scuba fatalities. Once a reported fatality has been verified through local authorities, information-gathering concerning the death is begun. DAN requests copies of autopsy reports, investigative agency reports and, if possible, statements from persons involved in the dive event. The analysis of this information is used to identify any common trends, factors, or conditions which are specific to scuba fatalities. The cause of death is best identified through autopsy reports and contributing factors are often provided through the witness or family interview. The quality of the analysis depends on the detail and accuracy of the reporting agencies and individuals. In some cases DAN may speak with the family regarding the deceased's medical history and experience level prior to the fatality.

The diving fatality falls under the jurisdiction of the local medical examiner, and the decedent is frequently subjected to forensic autopsy. DAN is able to obtain autopsy reports on many of these cases. This report is a retrospective, observational, analytical study of the 1992 cases. An autopsy report was available to DAN in 59 cases out of the 96 total cases, which represents 89 percent of all autopsied

## Figure 7.2 Primary Sources of Information

| | |
|---|---|
| Autopsy, medical/coroner report and family/witness interview | 10 |
| Autopsy and investigative report | 37 |
| Autopsy and family/witness interview | 3 |
| Autopsy and news clippings/local contact | 8 |
| Investigative report | 12 |
| Local contact | 5 |
| Family/friend report | 5 |
| Newspaper only | 16 |
| **TOTAL** | **96** |

cases. No body was recovered in nine incidents. Increased efforts at collection are resulting in more autopsy reports and descriptive incident summaries. These reports make it possible to define contributing medical conditions and individual behaviors which contribute to scuba fatalities.

Figures 7.3 and 7.4 show the location of scuba fatalities by state or by foreign location. No conclusion can be drawn concerning the relative safety or risk at any of the dive locations listed. Typically, deaths occur at a variety of dive sites and under various conditions. For example, the number of deaths in both Florida and California occurred at many different dive sites throughout the state.

## Figure 7.3 Location of Diving Fatalities by State

| | Certified | Uncertified | Unknown | Total | Percent |
|---|---|---|---|---|---|
| Florida | 15 | 5 | 2 | 22 | 22.9 |
| California | 12 | 2 | 1 | 15 | 15.6 |
| New Jersey | 5 | 0 | 0 | 5 | 5.2 |
| New York | 5 | 0 | 0 | 5 | 5.2 |
| Pennsylvania | 4 | 0 | 0 | 4 | 4.2 |
| Washington | 1 | 2 | 0 | 3 | 3.1 |
| Massachusetts | 2 | 0 | 1 | 3 | 3.1 |
| Missouri | 3 | 0 | 0 | 3 | 3.1 |
| Iowa | 2 | 0 | 0 | 2 | 2.1 |
| Louisiana | 2 | 0 | 0 | 2 | 2.1 |
| Hawaii | 1 | 0 | 1 | 2 | 2.1 |
| Rhode Island | 1 | 0 | 1 | 2 | 2.1 |
| Alaska | 1 | 0 | 1 | 2 | 2.1 |
| North Carolina | 2 | 0 | 0 | 2 | 2.1 |
| West Virginia | 0 | 1 | 0 | 1 | 1.0 |
| Ohio | 1 | 0 | 0 | 1 | 1.0 |
| Wisconsin | 1 | 0 | 0 | 1 | 1.0 |
| Texas | 1 | 0 | 0 | 1 | 1.0 |
| Alabama | 0 | 1 | 0 | 1 | 1.0 |
| New Mexico | 0 | 1 | 0 | 1 | 1.0 |
| Arkansas | 1 | 0 | 0 | 1 | 1.0 |
| Maine | 1 | 0 | 0 | 1 | 1.0 |
| Michigan | 1 | 0 | 0 | 1 | 1.0 |
| **Total** | **62** | **12** | **7** | **81** | **84.0** |

In addition, both Florida and California have a very heavy population of certified divers and are probably the most frequented U.S. diving states. The deaths in these two states may seem high, but there has been an overall decrease in the average number of deaths — in Florida by 10 deaths per year and in California by three deaths per year — since the 1980s.

There were 10 deaths in the combined geographic area of New York and New Jersey in 1992. From 1989 to 1991 there were 13 deaths in this region, averaging four deaths per year with a range of two to six deaths per year. There were five technical-level or technical divers who died on some of the deep and more advanced diving sites in the region in 1992. These technical deaths resulted in twice the average number of fatalities for New York and New Jersey.

**These technical deaths resulted in twice the average number of fatalities for New York and New Jersey.**

Although the number of U.S. citizens who died while scuba diving abroad increased from 13 to 15 in 1990, the percentage of deaths outside the United States decreased from 19.5 percent to 15.5 percent. There has been some overall decrease in deaths abroad since 1989 and 1990, when one out of every four scuba fatalities reported occurred in a foreign location or U.S. territory. Additionally, there was an average of 25 foreign deaths in 1989 and 1990 compared to an average of only 14 deaths for the past two years. There was an average of 12 U.S. fatalities in foreign countries or U.S. territories during the 1980s. The cumulative totals by state and foreign location since 1970 are shown in Appendix D of this report.

## Figure 7.4 Location of Diving Fatalities Outside the United States

| Country | Total | Percent |
|---|---|---|
| Mexico | 6 | 6.3 |
| US Virgin Islands | 2 | 2.1 |
| Saba | 2 | 2.1 |
| Bonaire | 1 | 1.0 |
| Canada | 1 | 1.0 |
| Cayman Islands | 1 | 1.0 |
| Saipan | 1 | 1.0 |
| Jamaica | 1 | 1.0 |
| **Total** | **15** | **15.5** |

# Fatality Dive Profile

**The divers' choice of activities should be consistent with their training, dive experience, and familiarity with different dive settings ... in order to minimize their exposure to risk.**

Certified divers can participate in various scuba activities such as pleasure diving, sightseeing, spearfishing, wreck diving, and cave diving. Special training and certification are often necessary to safely participate in these activities. Some activities such as wreck penetration or ice diving require increased skill levels and knowledge in order to handle more stressful dive situations. Divers' choice of activities should be consistent with their training, dive experience, and familiarity with different dive settings (such as deep diving, rough sea conditions or limited visibility) in order to minimize their exposure to risk.

Figure 8.1 shows the primary activity for both certified and non-certified divers who died in 1992. Primary activity implies the main purpose of the dive. For example, of the 12 divers who dived over 130 feet there were only five cases where the primary purpose of the dive was for depth. The primary activity of the other divers (wreck, cave, and photography) involved depth, but it was secondary. There is also an unknown category that represents divers whose certification was unknown but their activity was stated in their case report.

Most fatalities occur after a sudden or unexpected event while sightseeing or pleasure diving. Cave, ice, and wreck diving represent special dive activities that involve a solid overhead structure which prevents them from making a direct ascent to the surface. In the six cave diving deaths, only three were listed as certified cave divers, meaning they had acquired additional training but not necessarily additional experience. An additional fatality occurred in a certified cave diver who was deep diving (over 130 feet) but not cave diving at the time. The ice deaths were a double fatality in which neither individual had proper ice diving training. The total of 10 spear-fishing or hunting fatalities increased from five in the 1991 data, but there were eight and nine fatalities per year for 1989 and 1990, respectively.

Ninety-two percent of all fatalities in 1992 were certified divers. These deaths include 11 divers whose certification level could not be confirmed. Eight deaths, or 8 percent, of the fatalities were in uncertified divers. These were individuals who did not receive standard scuba training before attempting to dive. Six individuals were undergoing initial training and two individuals were undergoing

advanced open-water training when their mishaps occurred. There were no instructor deaths while providing scuba training.

There were 11 technical diver or technical-level diver deaths for 1992. These divers represent a unique group of trained divers. Their deaths have been reported in *technicalDIVER*™, a specialty publication in the dive field. Additionally, there were 10 other fatalities in which recreational divers attempted a technical-level dive without the proper training or equipment. Unlike recreational or sport diving, the technical divers choose to extend their diving range beyond established recreational limits. This may be done through special equipment, breathing mixtures and/or special training which can extend dive time limits, depths, and increase a diver's ability to perform a more stressful, strenuous, and otherwise arduous dive.

**Ninety-two percent of all fatalities in 1992 were certified divers.**

Technical diver deaths are generally characterized as being deep, or greater than 130 feet, and in an overhead environment such as a wreck or cave. Seven out of 11 divers were diving at depths greater than the recreational limit of 130 feet. Five of these divers were making planned dives to 200 or more feet. Seven of these deaths involved wreck diving. In two cases, the diver never reached the exit, in one case a diver was found on the bottom, and in three cases there was an observed event such as a seizure or a loss of consciousness underwater. In another case, a double fatality resulted after

## Figure 8.1 Primary Dive Activity

| Primary Dive Activity | Certified to Scuba Dive | Not Certified to Scuba Dive | Unknown | Total | Percent |
|---|---|---|---|---|---|
| Pleasure | 31 | 8 | 2 | 41 | 42.7 |
| Spearfishing/Hunting | 10 | 0 | 1 | 11 | 11.5 |
| Wreck | 11 | 0 | 0 | 11 | 11.5 |
| Under Instruction | 2 | 6 | 0 | 8 | 8.3 |
| Cave | 6 | 0 | 0 | 6 | 6.3 |
| Deep Dive (≥130 fsw) | 4 | 0 | 0 | 4 | 4.1 |
| Unknown | 0 | 0 | 5 | 5 | 5.2 |
| Work | 2 | 0 | 1 | 3 | 3.1 |
| Photography | 3 | 0 | 0 | 3 | 3.1 |
| Ice | 2 | 0 | 0 | 2 | 2.1 |
| Night | 2 | 0 | 0 | 2 | 2.1 |
| **TOTAL** | **73** | **14** | **9** | **96** | **100.0** |

some difficulty began during a wreck penetration dive. There was a direct ascent to the surface without appropriate decompression stops.

**... there were 10 recreational divers who attempted technical-level diving without appropriate training or equipment.**

Additionally, there were 10 recreational divers who attempted technical-level diving without appropriate training or equipment. This includes two ice divers, three cave divers, a double fatality, and a separate single fatality, where individuals were attempting deep (greater than 130 feet) dives and two individuals who were diving on mixed gas but did not have mixed-gas dive training.

Figure 8.2 shows the dive platform used by all divers to enter the water. The largest number of fatalities occurred after a shore entry. Charter boat and private boat fatalities were nearly evenly divided. The numbers are very small in each category, so little significance can be drawn from the small decrease in shore fatalities or increase in private boat fatalities. Sufficient information was not available in four cases to determine the dive platform, but they were all ocean fatalities.

## Figure 8.2 Dive Platform

| | 1992 | | 1991 | 1990 |
|---|---|---|---|---|
| Entry | Frequency | Percent | Percent | Percent |
| Shore | 36 | 39.1 | 46.0 | 45.0 |
| Charter Boat | 29 | 31.5 | 30.2 | 35.0 |
| Private Boat | 26 | 28.3 | 22.2 | 20.0 |
| Pool | 1 | 1.1 | 1.6 | |
| **Total** | **92** | **100.0** | **100.0** | **100.0** |

*Frequency Missing* = 4

Figure 8.3 shows the number of individuals in the dive group at the time of the fatality. This includes all divers or individuals associated with the event including boat personnel. This may also represent the total number of people at the scene. Other people may have been present in the area but not directly involved and at some distance to the dive group or individual. Sixty-three percent of all scuba fatalities occurred in groups of four or fewer divers. Forty-two percent of all fatalities occurred in groups of two divers or individuals solo diving. The 29 deaths in the two diver group is the largest number reported since 1989.

Many problems can arise during a dive that contribute to a dive accident. Diving solo or in small groups decreases the availability of assistance when emergency situations occur. Successful outcomes to emergency underwater events are less likely if no one witnesses the

## Figure 8.3 1992-Number of Divers in a Group (as of 12/3/93)

| Number in Dive Party | Frequency | Percent |
|---|---|---|
| 1 | 4 | 5.1 |
| 2 | 29 | 36.7 |
| 3 | 13 | 16.4 |
| 4 | 4 | 5.1 |
| 5 | 3 | 3.8 |
| 6 | 3 | 3.8 |
| 7 | 3 | 3.8 |
| 8 | 4 | 5.1 |
| 9 | 0 | 0 |
| ≥10 | 16 | 20.2 |
| **TOTAL** | **79** | **100.0** |

*Frequency Missing = 17*

event or if no one is available to offer immediate assistance from a boat offshore when it is requested.

Figures 8.4 and 8.5 show the time (when) and the phase (where) of the dive that events occurred leading to a fatality. These categories are approximations since exact times are difficult to obtain. The frequency missing for both tables represents four cases where the available information was extremely limited. The unobserved events refers to deaths where there was no witness to the event. Included in this group would be five solo divers and double fatalities where there were only two members in the dive party.

Some of the fatalities which occurred early in the dive and late in the dive as well as those occurring on the surface were due to cardio-vascular or other medical conditions. A general lack of fitness also may have added to physical stress problems in obese divers. The need for swimming at the surface post-dive or the sudden need for exertion at the beginning of the dive are thought to trigger physical stresses in those divers with cardiovascular disease and obesity. The demand for strenuous exercise may have triggered cardiac arrhythmias and result in an inappropriate physical response when needed.

**The need for swimming at the surface post-dive or the sudden need for exertion at the beginning of the dive are thought to trigger physical stresses in those divers with cardiovascular disease and obesity.**

**A single event can often trigger a series of events that can result in a diving fatality.**

A single event can often trigger a series of events that can result in a diving fatality. For example, 27 individuals ran out of air, and eight were low on air. In the 22 cases of rapid ascent only six were caused by an out-of-air situation, and four were caused by low-air situations. Insufficient air as the initial problem caused the rapid ascent. In a similar manner, some divers may have run out of air as a secondary event because they became entangled (six cases), or trapped (nine cases). In the entangled or trapped diver cases, three occurred in the dive period of the dive. Two of the rapid ascents occurred in the mid, late, or post-dive period also. Of the five remaining cases, two occurred early in the dive, and three cases were unobserved.

Buddy separation was reported to have occurred in 41 of the 96 cases. This does not include five divers who were solo diving. The exact time the distress occurred in these individuals can only be approximated. In 35 cases, which include two solo divers, a buddy or surface observer noted a diver to be in distress. An immediate search for assistance was begun in 56 cases once a diver was noted to be missing or in distress. The majority of divers, which includes those in distress at the surface, never dropped the weight belt. It is important to note that this action is a secondary or tertiary event and is unlikely to occur unless the previous series of events is successfully handled.

## Figure 8.4 When Problem Occurred

| | Frequency | Percent |
|---|---|---|
| Surface-Predive | 5 | 5.4 |
| Immediately | 4 | 4.3 |
| Early Dive | 15 | 16.3 |
| Mid Dive | 11 | 12.0 |
| Late Dive | 26 | 28.3 |
| Post Dive | 16 | 17.4 |
| Unobserved | 15 | 16.3 |
| **TOTAL** | **92** | **100.0** |

*Frequency Missing* = 4

## Figure 8.5 Where Problem Occurred

| | Frequency | Percent |
|---|---|---|
| Surface-predive | 5 | 5.4 |
| Descent | 11 | 12.0 |
| At Depth | 22 | 23.9 |
| During Ascent | 22 | 23.9 |
| Surface Post Dive | 17 | 18.5 |
| Unobserved | 15 | 16.3 |
| **TOTAL** | **92** | **100.0** |

*Frequency Missing* = 4

# Dive Fatalities Among Certified Diver Population

This section deals only with certified scuba divers and includes the 11 individuals whose certification was unknown. There have been 367 recreational scuba fatalities since 1989, so the trends shown here relate only to the recent years of study. Table 9.1 shows the age for the 88 certified fatalities in 1992. Ages ranged from 14 to 71 years of age. The percentage of fatalities in individuals who were in their 20s, 30s, or 40s has not varied by more than 3 or 4 percent since 1989. However, this age range made up 66.7 percent of all fatalities in 1989 but now makes up 84 percent in the 1992 scuba deaths. There is a corresponding decrease in the number of scuba fatalities in individuals 50 years of age or older. In 1989 there was a high of 28 scuba deaths, which resulted in one out of every four scuba fatalities that year. The number of deaths and percentage of total deaths in this age range has decreased consistently since 1989 and now makes up only 12 deaths and 13.6 percent of the total yearly deaths. The 10- to 19- year-old age range has also shown a small decrease in the number of scuba fatalities since 1989. The percentage of female scuba divers in the certified population has gone from 10 percent in 1989 to 25 percent in 1991, the highest level to date. Females represent 20 percent of the 1992 deaths.

**The percentage of female scuba divers in the certified population has gone from 10 percent in 1989 to 25 percent in 1991, the highest level to date. Females represent 20 percent of the 1992 deaths.**

## Figure 9.1 Age and Sex Comparison of 1992 Fatalities

| Age | Male | Female | Total | Percent |
|---|---|---|---|---|
| 10-19 | 1 | 1 | 2 | 2.3 |
| 20-29 | 13 | 5 | 18 | 20.5 |
| 30-39 | 24 | 4 | 28 | 31.8 |
| 40-49 | 22 | 6 | 28 | 31.8 |
| 50-59 | 8 | 2 | 10 | 11.4 |
| 60-69 | 1 | 0 | 1 | 1.1 |
| 70-79 | 1 | 0 | 1 | 1.1 |
| **Total** | **70** | **18** | **88** | **100.0** |

Figure 9.2 shows the highest level of certification in the 1992 scuba fatalities. The majority of scuba fatalities (58 percent) occurred in divers with basic open-water certification or who were participating in initial training. Two open-water students were also undergoing an advanced open-water class. There were eight deaths among certified divemasters — seven more than there had been in the previous two years. With the exception of four certified cave divers, most numbers remain the same. There were no deaths among certified cave divers in 1991, but there were four cave diving deaths in 1990.

**Forty-eight percent of all fatalities had less than 20 dives within their specific activity.**

There were 11 unknown certifications included in the certification level table. These fatalities were included because the somewhat limited available information suggested dive settings where uncertified divers would typically not be admitted. For example, one case included information from a family friend who is a certified diver. He spoke of diving frequently with the deceased. In another case, the county coroner commented that he knew the decedent was certified. The level of certification and experience was unknown in both cases.

The diving experience of the 1992 fatalities is shown in Figure 9.3. This Figure compares the overall diving experience since becoming certified to the experience of that individual within the special activity they were performing when the fatality occurred. Reference may be made to Figure 8.1 showing dive activity. Twenty-five percent (25) of the scuba fatalities occurred in divers with overall experience of 20 or less dives. Forty-eight percent (48) of all fatalities had less than 20 dives within their specific activity. At least 26

## Figure 9.2 Certification Level of 1992 Fatalities

| | | |
|---|---|---|
| Student* | 6 | 6.8% |
| Basic/Open Water | 47 | 53.4% |
| Advanced | 11 | 12.5% |
| Dive Master | 8 | 9.1% |
| Instructor | 2 | 2.3% |
| Cave | 4 | 4.6% |
| Cavern | 1 | 1.1% |
| Unknown | 9 | 10.2% |
| **Total** | **88** | **100.0%** |

**Under initial training.*

percent (26) of the scuba fatalities had 61 dives or more in overall experience, and 13 percent were very experienced within their activity. Twenty-one (21) divers (approximately one in four) were not placed in a specific experience category because information was insufficient.

The high percentage of individuals with only open-water certification and the percent of individuals with limited experience within their activity indicate that some scuba deaths might be avoided with more training and experience prior to entering a new diving situation. Figures 9.2 and 9.3 also show that divers with higher certifications and more experience are not exempt from scuba accidents resulting in fatalities. The risk of injury and death cannot be completely eliminated, but more training and dive experience are encouraged as preventive measures.

The eight uncertified divers were excluded from analysis in this section so that only certified or divers with unknown certification levels may be considered. These eight deaths were all in male divers ranging in age from 18 to 51. Improperly assembled, borrowed, or defective equipment contributed to the incident in four cases, alcohol consumption was a factor in three cases, with one case also involving a medical condition which could contraindicate scuba diving. In one case, an individual was diving solo without the possibility of rescue. It is generally unusual to find this many potentially lethal factors in eight randomly selected fatality cases that were certified to dive.

**The high percentage of individuals with only open-water certification and the percent of individuals with limited experience within their activity indicate that some scuba deaths might be avoided with more training and experience prior to entering a new diving situation.**

## Figure 9.3 Diving Experience in Fatalities

| | Within Activity or Environment | | Overall Experience | |
|---|---|---|---|---|
| Student | 6 | 7% | 6 | 7% |
| Novice (≤ 5 dives) | 29 | 33% | 6 | 7% |
| Inexperienced (6 - 20 dives) | 7 | 8% | 10 | 11% |
| Intermediate (21 - 40 dives) | 11 | 13% | 15 | 17% |
| Advanced (41 - 60 dives) | 3 | 2% | 7 | 8% |
| Experienced (≥ 61 dives) | 11 | 13% | 23 | 26% |
| Unknown | 21 | 24% | 21 | 24% |
| **TOTAL** | **88** | **100%*** | **88** | **100%*** |

**Percent of certified divers*

# Medical Issues in Scuba Fatalities

**A recreational scuba fatality is not a random event. The fatality may be an accident, the result of pre-existing disease, or both.**

## Causes of Death

The fatalities in this report were assigned cause of death and contributing factors using the *International Classification of Disease Clinical Modification* (ICD-9-CM) based on the World Health Organization's *International Classification of Diseases*[1]. The ICD-9-CM codes which were used are listed in Appendix G. The cause of death as listed on the death certificate was accepted in the majority of cases when the death certificate or autopsy report was available. In other cases the cause of death was determined based on the information available. In a few cases, there was insufficient information available.

A recreational scuba fatality is not a random event. The fatality may be an accident, the result of pre-existing disease, or both.

There are identifiable causal factors. These include the following:
- Inadequate training/experience
- Equipment needs
- Equipment defects
- Equipment hazards.

There are identifiable host factors. These include the following:
- Age
- Pre-existing disease
- Physical fitness
- Alcohol/drugs.

## Cardiovascular Disease — Immediate Cause of Death

Cardiovascular disease is a prominent immediate cause of death among the 1992 fatalities. The divers involved are all past 40 years of age, indicating caution for divers in this age range.

Heavy physical exertion sometimes precedes and even appears to precipitate the onset of acute myocardial infarction (heart attack). A recent study[2] has confirmed the link between heavy exertion and the onset of myocardial infarction. However, this excess risk of heart attack during exertion is limited for the most part to persons who do not exercise regularly.

Divers 40 or over may require a comprehensive examination and periodic reexamination to detect the presence of coronary artery disease (CAD). If divers have evidence of CAD, diving should be avoided until treatment has been established and consultation with a diving physician obtained to confirm that physical fitness for diving is satisfactory.

Measures to minimize the risk of CAD related deaths may be useful for divers. A consistent aerobic exercise program four to five times per week is essential for divers of all ages and particularly for those in the age group at risk for CAD. The protective effect of regular exercise is very strong [3, 4]. Regular exercise may also help to prevent the development and progression of CAD.

**A consistent aerobic exercise program four to five times per week is essential for divers of all ages and particularly for those in the age group at risk for coronary artery disease.**

## Drowning Deaths/Contributing Medical Cause Other Than Cardiovascular

Diabetes mellitus and bronchial asthma do not appear prominently in this series. There were two diabetic and two asthmatic diver deaths in 1992.

## Figure 10.1 Contributing Factors to Drowning

| Contributing Factors | Number of Divers |
|---|---|
| Insufficient Air | 22 |
| Entrapment | 12 |
| Cardiovascular | 4 |
| Alcohol/Drugs | 4 |
| Panic State | 4 |
| Nitrogen Narcosis | 3 |
| Air Embolism | 7 |
| Obesity | 3 |
| Rapid Ascent | 3 |

## Reports of Autopsied Cases

Autopsy information is essential for the complete investigation of the diving fatality. The autopsy may disclose unsuspected cardiovascular disease as a cause of death or may confirm known cardiovascular disease as the cause. An autopsy without pathognomonic findings of any disorder is consistent with drowning and is important information to have.

Autopsy reports and dive records available to DAN were reviewed on all deaths which occurred to United States citizens or to anyone in U.S. waters while engaged in recreational scuba diving during the year 1992. There were 96 cases collected by DAN during the period. The selection of cases for analysis is determined by the availability of a reasonably complete accident and autopsy report.

Autopsies were performed by various medical examiner jurisdictions on 68 of the 87 fatality cases whose bodies were found during 1992.

**DAN collects data on all diving fatalities. The discussion in this report is limited, however, to recreational and technical divers.**

The bodies of nine of the 1992 victims disappeared. For 1992, DAN received an autopsy report in 59 incidents, representing 61 percent of total cases and 87 percent of the autopsied cases. There is no attempt to establish any type of statistical data such as incidence or occurrence rates due to the numerous sources of bias in the selection method as well as in observation.

## Diver Categories

**C — Commercial** *see Appendix F*
Divers involved in a task for which they expect some type of compensation. They may be recreational divers employed temporarily for a job (for example, recovery of a lost object), or full-time career divers.

**S — Scientific**
Divers engaged in research and usually associated with an academic institution.

**R — Recreational**
Those divers whose main purpose is enjoyment of the underwater environment.

**TD — Technical Diver**
Recreational divers attempting to use special techniques to penetrate overhead environments or to achieve depths not considered within the usual boundaries of recreational diving. Special equipment and gas mixes are frequently utilized.

DAN collects data on all diving fatalities. The discussion in this report is limited, however, to recreational and technical divers.

## Cerebral Arterial Gas Embolism

There were 13 deaths attributed to cerebral arterial gas embolism, of which eight were drowning deaths. There were a variety of causes of the cerebral air embolisms, including air supply problems, panic, a sub-pleural bleb, and possibly breath-holding. The cases are described in detail below.

The combination of insufficient air and rapid ascent appears to be the major factors in the cause of air embolism. Both of these factors result from diver error.

Each year a few fatalities due to air embolism occur during training exercises. Ascent training will continue to produce a rare fatality. The decision concerning ascent training must balance this fact against any overall benefit to all divers.

## Conclusions

### Autopsy

Autopsy information is essential for the complete investigation of the diving fatality. The autopsy assists in determining the cause and manner of death, provides benefit to the family, provides useful legal information and provides vital statistics and research benefit.

**The combination of insufficient air and rapid ascent appears to be the major factors in the cause of air embolism. Both of these factors result from diver error.**

### Drowning

The factors contributing to the drowning death are under the control of the diver. Consequently, the ultimate cause of essentially all scuba drownings is diver error. It is therefore possible to reduce substantially the number of drowning deaths by improving diver skills.

Finally, it appears that the diver is responsible for the error that leads to a fatality in the vast majority of cases. This may be due to inadequate knowledge and skills or simple ineptness. The training agencies are clearly challenged to improve the training process and promote continuing the training process throughout the diver's career.

A diving fatality may be viewed as a consequence of a breakdown in preventive practices and should stimulate a re-examination of these preventive practices. This report has identified many factors involved in the fatal scuba accident and suggested improvement in diver selection and training as one means of reducing the number of fatalities.

[1] *International Classification of Diseases — Clinical Modification* (9th Revision), U.S. Department of Health and Human Services, Public Health Services, Health Care Financing and Administration.
[2] Mittleman, MA, MacIre M, Tofler GH, Sherwood JB, Goldberg RJ, Muller JE. Triggering of acute myocardial infarction by heavy physical exertion — protection against triggering by regular exertion. N Engl J Med 1993:329:1677-83.
[3] Mittleman, MA, *op cit.*
[4] Willis SN, Lewis M, Lowel H, Arntz H-R, Schubert F, Schroder R. Physical exertion as a trigger of acute myocardial infarction. N Eng J Med 1993:329:1684-90.

# Appendix A – Fatality Case Reports

## Air Embolism

**DAN Record Number:** 2492 **Birth Year:** 1950 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Air embolism | 958.0 |
| **Due to**: Rapid ascent | E902.2 |
| **Due to:** Scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Coronary atherosclerosis, mild | 414.9 |
| **Due to:** Pulmonary edema | 428.1 |

The decedent and his daughter were diving in a mountain lake with a group of family and friends. The 13-year-old daughter developed difficulty of some type and was apparently unconscious at about 30 feet. The decedent managed to bring her to the surface where he himself developed cardiac arrest.
The autopsy disclosed evidence of cerebral air embolism and mild coronary artery disease. The daughter survived for a few hours and died at the hospital.

**DAN Record Number:** 8692 **Birth Year:** 1951 **Sex:** Male
**Diver Category:** TD

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Air embolism | 958.0 |
| **Due to:** Entrapment, cave | E918.2 |
| **Due to**: Recreational scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Fatty liver, mod. severe | 571.8 |
| 2. Cirrhosis, portal, early | 571.2 |
| 3. Emphysema, interstitial | 492.8 |

The decedent and a friend had completed a cave dive and were making their way to the exit when the friend noted that the decedent was no longer following. The friend searched and found the decedent unresponsive with the regulator out of the mouth. He was not able to perform rescue and was forced to make an ascent without decompression stops resulting in decompression sickness. The decedent was later recovered about 275 feet into the cave system up against the cave ceiling at a depth of 100 feet .

The autopsy was thorough and disclosed evidence of drowning and air embolism.

**DAN Record Number:** 5692 **Birth Year:** 1952 **Sex:** Female
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Air embolism | 958.0 |
| **Due to:** Recreational scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. S/P repair of atrial septal defect | 35.7 |
| 2. Cardiomyopathy, secondary unspec. | 425.9 |

The decedent had been a diver of several years' experience. About nine months prior to death she developed exertional dyspnoea (difficulty in breathing when exerted) and was found to have an atrial-septal defect. This was surgically repaired, and she was cleared to resume diving after echo study did not disclose a shunt.

She was on a charter boat making her first dive since surgery with a group of divers not known to her. Her assigned buddy was an experienced diver who observed that she was having difficulty during descent. He lost sight of her and began to ascend the anchor line when she sank past him head-first with her regulator out of her mouth. She sank all the way to the bottom before her buddy reached her and with assistance brought her to the surface. CPR was attempted on the boat by several off-duty police officers.

The autopsy disclosed a large, flabby heart. The medical examiner felt the cause of death to be air embolism.

**DAN Record Number:** 792 **Birth Year:** 1964 **Sex:** Female
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Air embolism | 958.0 |
| **Due to:** Rapid ascent | E902.2 |
| **Due to:** Insufficient air | E913.2 |
| **Due to:** Scuba diving | E910.1 |

The decedent was diving from a charter boat in a coastal area. The decedent had made one dive with no difficulty and was paired with a different buddy for the afternoon dive. The male buddy had a 90-cubic-foot 3,300psi cylinder and the decedent had a 60-cubic-foot 3,000psi cylinder. They agreed that when the decedent's air became low she would return to the vessel, and he would continue the dive. They followed this procedure, and when the male returned to the vessel the decedent was not there. An unsuccessful topside search was begun with assistance of the U.S. Coast Guard and other vessels. The charter vessel returned to the site the following day with expert divers who recovered the decedent's body at 55fsw still wearing the weight belt. The weight belt was discarded by the diver who recovered the body as he could not otherwise raise her.

Autopsy findings disclosed the presence of postmortem animal bites but no other signs of injury. There were large numbers of small air bubbles in the subarachnoid space over the entire cerebral cortex. The impression of the pathologist was cerebral air embolism. This represents the failure of the buddy system with a mismatched buddy pair who were strangers to one another prior to the dive.

**DAN Record Number:** 6292 **Birth Year:** 1949 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Air embolism | 958.0 |
| **Due to:** Scuba diving | E910.1 |

The decedent and his buddy were making their third dive of the day in offshore waters. The previous two dives had been uneventful and the third dive ended with a planned ascent from 65fsw. The decedent developed problems while surfacing and sank to the bottom. He was found by other divers who were surfacing and brought to the surface, where resuscitation was not possible.

The autopsy was consistent with air embolism.

**DAN Record Number:** 4092 **Birth Year:** 1943 **Sex:** Female
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Air embolism | 958.0 |
| **Due to:** Rapid ascent | E902.2 |
| **Due to:** Scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Subcutaneous emphysema | 958.7 |

The decedent and her husband were divers of limited experience (18 dives) who were quarry diving and exceeded their planned depth. The husband signaled to ascend and thought his wife was with him. She did not ascend, and he returned to her one time and again thought she was ascending with him. However, at the surface he could not find her. The body was located two days later in 127 feet of water.

Autopsy was consistent with drowning and air embolism. There was intracardiac and intravascular air present as well as subcutaneous and mediastinal air.

**DAN Record Number:** 9592 **Birth Year:** 1955 **Sex:** Male
**Diver Category:** TD

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Air embolism | 958.0 |
| **Due to:** Rapid ascent | E902.2 |
| **Due to:** Scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Nitrogen narcosis | 293.0 |
| 2. Exogenous obesity | 278.0 |

The decedent and his companion were diving to 232 feet. During ascent at 215 feet the decedent became unconscious and lost his regulator. He was brought to the surface by his buddy and was essentially dead at the surface, although resuscitation was attempted. The report states that the dive began at 1125 hours and the ambulance was called at 1134 hours, nine minutes later.

At autopsy there was gas in the right heart and epicardial veins. The brain is described as showing cerebral edema, but there is no mention of gas in vessels. The cause of death may have been coronary air embolism or cerebral air embolism or both. The instant death plus air in the epicardial veins suggests coronary air embolism.

**DAN Record Number:** 7392 **Birth Year:** 1958 **Sex:** Male **Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Cerebral air embolism | 958.0 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Multiple subpleural blebs | 492.0 |
| 2. Apical pulmonary emphysema | 492.8 |
| 3. Bilateral pleural effusions | 511.1 |
| 4. Pulmonary edema | 508.9 |

The decedent and his girlfriend were diving in 18fsw, and both experienced difficulty with their regulators. The decedent apparently offered the girlfriend his own regulator, which she did not take. He then "began foaming at the mouth" and became unconscious. The girlfriend could not rescue the decedent, but did secure his body.

The autopsy disclosed air in the cerebral veins as well as the major pulmonary findings listed. The subpleural blebs may have been the source of the air.

**DAN Record Number:** 4292 **Birth Year:** 1947 **Sex:** Male
**Diver Category:** TD

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Air embolism | 958.0 |
| **Due to**: Rapid ascent | E902.2 |
| **Due to:** Insufficient air | E913.2 |
| **Due to:** Scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Nitrogen narcosis | 293.0 |

The decedent was diving with a companion on a wreck at 171fsw and was using two cylinders with independent regulators. He was wearing a dry suit connected to his breathing gas supply. As the two divers were ascending; the decedent indicated a problem, then became unresponsive, and finally

unconscious. His buddy attempted to deal with the situation by dropping decedent's weight belt. The decedent floated to the surface while the buddy completed his obligatory decompression stop. At the surface, the decedent was floating face-down and did not respond to resuscitation.

Examination of the equipment revealed that the cylinder in use had only 150psi while the other cylinder still contained 2,700psi. Evidently the decedent failed to switch to his alternate regulator and cylinder. During the free ascent to the surface, air embolism occurred. Nitrogen narcosis and hypercapnia ($CO_2$ retention) may have contributed to impaired judgement or psychosomatic coordination problems.

Autopsy findings are significant in the finding of gas bubbles in the pulmonary artery and Circle of Willis. Although these could have formed postmortem they probably represent air embolism due to rapid ascent.

**DAN Record Number:** 6892 **Birth Year:** 1951 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Cerebral Air embolism | 958.0 |
| **Due to:** Rapid ascent | E902.2 |
| **Due to:** Insufficient air | E913.2 |
| **Due to:** Scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Pulmonary emphysema, moderate | 492.8 |

While diving in approximately 20 to 25 feet of water with two friends, this 41-year-old male indicated a nonspecified problem, and they all surfaced. While they were on the surface, he told the friends he would snorkel back to the shore. Approximately two minutes later, when the two friends surfaced again, they found him approximately 50 feet from shore, face-up, and unresponsive. They brought him to shore and started CPR, which was unsuccessful.

The air cylinder which he had used was found empty.

The autopsy disclosed air in the blood vessels of the brain. Death appears to have been clearly due to air embolism following an out-of-air situation and probably breath-holding.

**DAN Record Number:** 3892 **Birth Year:** 1958 **Sex:** Male
**Diver Category:** TD

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Air embolism | 958.0 |
| **Due to:** Recreational scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Hypertension | 401.9 |

The decedent was a very experienced diver who frequented deep wrecks. He used mixed gases on the deep dives. His final dive was on a wreck with depth 135fsw. He was using a 38-percent oxygen-nitrogen mixture, which equals 1.88atm $PO_2$ at 135fsw. The decedent was found unconscious on the bottom. He was carried to the decompression stop by his companion and then allowed to float to the surface because of the companion's decompression obligation.

Autopsy showed air columns in the Circle of Willis at the base of the brain and the left ventricle of the heart. These may have been air emboli or postmortem bubbles. The cause of loss of consciousness may have been an oxygen seizure in view of the high $PO_2$ in the mix.

**DAN Record Number:** 892 **Birth Year:** 1965 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Air embolism | 958.0 |
| **Due to:** Rapid ascent | E902.2 |
| **Due to:** Recreational scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Panic state | 308.0 |

The decedent was a 26-year-old male, making the second of two planned training dives for certification. He developed difficulty with his air supply about 20 minutes into the dive. He was assisted by his instructor, but would not buddy breathe and ascended rapidly to the surface. He became unconscious at about 10 feet. He was rescued promptly, but there was great difficulty in getting him into the boat.

The autopsy disclosed bubbles in the cerebral vasculature.

The scuba cylinder contained 900psi when examined and the regulator was functioning normally.

**DAN Record Number:** 8092 **Birth Year:** 1956 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Air embolism | 958.0 |
| **Due to:** Rapid ascent | E902.2 |
| **Due to:** Insufficient air | E913.2 |
| **Due to:** Scuba diving | E910.1 |

Decedent was a 36-year-old male participating in an advanced open-water training dive to 90 feet in a mountain lake. During the ascent he ran out of air and made a rapid ascent while attempting buddy breathing on an octopus regulator. At the surface he was in respiratory arrest, and by the time shore was reached, he was in cardiopulmonary arrest.

The autopsy revealed air in cerebral vessels over wide areas with mass effect.

# Cardiovascular Disease — Immediate Cause of Death

**DAN Record Number:** 2892 **Birth Year:** 1950 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Arteriosclerotic heart disease | 414.0 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Recreational scuba diving | E910.1 |
| 2. Cardiomegaly | 429.3 |

Decedent was a 41-year-old male preparing to dive with friends in a freshwater lake. The dive team had made a short swim and then switched to regulators from snorkels. The decedent was observed to take a few breaths on his regulator; he then rolled over on his back without descending. He was immediately rescued by his companions who found him in cardiac arrest. CPR was initiated in the water, continued on the boat and during helicopter evacuation. He was dead on arrival (DOA) at local hospital.

Autopsy disclosed the presence of coronary artery disease.

**DAN Record Number:** 3192 **Birth Year:** 1920 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Coronary atherosclerosis | 414.0 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Aspiration of sea water (drowning) | 994.1 |
| 2. Pulmonary edema | 428.1 |
| 3. Recreational scuba diving | E910.1 |
| 4. S/P hip replacement | 81.59 |

This diver was a 71-year-old retired male reported in excellent physical condition. He was diving with a companion for abalone and, as was their custom, they separated to hunt. The younger man returned to the boat and waited for a time before searching. He reported that he followed a seal to the decedent's body. The autopsy disclosed coronary artery disease. The medical examiner stated, "The cause of death on this case is attributed to the atherosclerotic heart disease. In my opinion, the decedent developed severe myocardial ischemia due to marked narrowing of all major coronary arteries. As a consequence of this, he probably lost consciousness and during this period, he aspirated sea water. This condition led to the development of severe pulmonary edema."

**DAN Record Number:** 6992 **Birth Year:** 1951 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Aortic stenosis | 395.0 |
| **Due to:** S/P rheumatic fever | 391 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Recreational scuba diving | E910.1 |

This individual had been diving for about five years, although the level of experience is not reported. He was making an ocean dive when he was observed with his regulator out of his mouth. Companions attempted unsuccessfully to provide decedent with alternate air source, but he became unresponsive and on the surface was in cardiac arrest. Resuscitation efforts at scene and chamber were unsuccessful.

Autopsy findings:
- Head and central nervous system — within normal limits
- Cardiovascular — abnormal aortic valve with all three cusps thickened three to four times normal. Left and right coronary cusps fused at the commissure. Heart size normal.
- Balance of autopsy within normal limits.

This was a case of unrecognized aortic stenosis in an individual who had an episode of rheumatic fever many years prior to death. His hemodynamics probably gradually deteriorated as he aged and the exertion associated with the dive led to sudden death.

The relationship of exercise, aortic stenosis, and sudden death is well known.

**DAN Record Number:** 7192 **Birth Year:** 1939 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Myocardial infarction | 410.9 |
| **Due to:** Coronary artery disease | 414.0 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Scuba diving | E910.1 |
| 2. S/P coronary artery bypass graft (3) | 36.13 |
| 3. Tobacco abuse | 305.1 |
| 4. Cholelithiasis | 574.5 |

Decedent was a 53-year-old male with known coronary artery disease and triple coronary artery bypass graft procedure. He was cleaning the bottom of his boat using rented scuba gear. After he failed to surface, searchers found him sitting on the bottom with regulator out of his mouth. The autopsy disclosed the cause of death.

**DAN Record Number:** 9792 **Birth Year:** 1947 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Coronary atherosclerosis | 414.0 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Scuba diving | E910.1 |

Decedent had been diving alone on a beach when he was discovered to be unresponsive. He was taken to the Emergency Department at a local hospital, but was dead on arrival.

Autopsy report is complete and discloses the presence of coronary atherosclerosis, which was the cause of death.

## Drowning Deaths/Contributing Cause Cardiovascular

**DAN Record Number:** 292 **Birth Year:** 1942 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Recreational scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Coronary atherosclerosis | 414.0 |
| 2. Left ventricular hypertrophy | 429.3 |
| 3. S/P excision of pineal gland | 07.54 |

This was a 72-inch 220-pound male with significant past medical history including surgery for a brain tumor, medication and diet for hyperlipidemia, and the medication Tegretol™ for seizure prevention. He had been taking Tegretol for about 3 years and had discontinued three days prior to death. Information from the attending physician is not available. There is a statement in the interview that decedent had a stroke four or five years prior to death. No details of the diagnosis are given.

According to the wife's statement decedent had not completed a scuba course but had taken lessons two years prior to death. Apparently the incident dive was a check-out dive for open-water certification.

The decedent and his son dived together and were at 50fsw on the bottom when the son noted that the decedent was unresponsive and regulator was out of his mouth. He was brought to the surface, but could not be resuscitated.

Summary of autopsy findings.
- External — There was a supraumbilical laparotomy scar.
- Heart — Air bubbles in left and right coronary arteries. Concentric left ventricular hypertrophy.
- Brain — Evidence of surgical procedure right frontal lobe. Brain apparently normal.

This drowning resulted as a result of syncope and possibly cardiac arrest occurring at depth. The cause of the arrest may have been due to the coronary artery disease with left ventricular hypertrophy as a marker for sudden death. The other possibility is a seizure resulting from the discontinuance of Tegretol three days prior.

**DAN Record Number:** 1092 **Birth Year:** 1960 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Recreational scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Cardiomegaly | 429.3 |
| 2. Hypertrophic cardiomyopathy | 425.4 |
| 3. Cannabinoids present | E980.3 |

Decedent was diving with two companions and became separated from them during the dive. When he failed to reappear at the boat, the U.S. Coast Guard was notified, and decedent was found after a search. Newspaper reports state that tank still contained air and regulator was in decedent's mouth. The body was floating and was spotted by a tow boat.

The hypertrophic cardiomyopathy suggests that a dysrhythmia may have caused the loss of consciousness, leading to drowning.

**DAN Record Number:** 1492 **Birth Year:** 1944 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Insufficient air | E913.2 |
| **Due to:** Scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Hypertensive cardiovascular disease | 402.0 |
| 2. Cardiomegaly | 429.3 |
| 3. Multiple nodules thyroid gland | 241.1 |
| 4. Diabetes mellitus | 250.0 |

Toxicology studies at autopsy detected nordiazepam, propoxyphene, and phenylproponolamine.

The medical examiner report leaves cause of death as "pending." Our review indicates that this was a drowning due to insufficient air.

The report indicates that decedent was non-compliant in control of his hypertension and diabetes as well as subject to panic attacks. Two days prior to dive he experienced an episode of chest pain severe enough to make him stop his car until the pain subsided. The origin of the pain is not known.

**DAN Record Number:** 4992 **Birth Year:** 1935 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Arteriosclerotic heart disease | 429.2 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Recreational scuba diving | E910.1 |

The decedent was a 57-year old-executive who had accompanied his fiancée and instructor on an open-water training dive. Visibility was five feet and the decedent's disappearance was not noted. The body was not recovered for over 24 hours.

Autopsy disclosed severe coronary artery disease. Toxicology results were negative.

## Drowning Deaths/Contributing Medical Cause Other Than Cardiovascular

### *Diabetes Mellitus*

**DAN Record Number:** 4192 **Birth Year:** 1972 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Anoxic brain damage | 348.1 |
| **Due to:** Near-drowning | 994.1 |
| **Due to:** Hypoglycemia due to insulin | 251.0 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Diabetes mellitus | 348.1 |
| 2. Scuba diving | E910.1 |

This was a 19-year-old student with a four-year history of insulin-dependent diabetes. According to the investigative report, he had episodes of insulin-related hypoglycemia.

In summary, the decedent was participating in a scuba course in a university swimming pool. He was last observed at the pool edge while the class was leaving the pool to prepare for another exercise. Several minutes elapsed before he was missed and discovered on the bottom of the pool in eight feet of water. He was rescued by classmates and resuscitated by EMS, but died about 48 hours later.

His blood sugar had been determined by paramedics while en route to hospital and was 80mgm%. However, he had received 37 mgm epinephrine prior to the determination. This epinephrine plus the catecholamine release during the near-drowning episode undoubtedly had elevated his blood sugar from significantly hypoglycemic levels.

## *Other Medical Contributing Causes*

**DAN Record Number:** 692 **Birth Year:** 1964 **Sex:** Female
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Respiratory insufficiency | 786.09 |
| **Due to:** Left ovarian serous cystadenoma, massive | 220. |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Recreational scuba diving | E910.1 |

This young woman went into a water-filled mine with a guided group and developed unknown difficulties shortly after beginning dive. She disappeared and apparently was not noted to be missing for about 20 minutes. She was discovered by another dive group returning to the entry point.

Summary of autopsy findings.
- External — negative except signs of resuscitation attempts.
- Body cavities — On removal of the chest plate, the diaphragms are markedly shifted upward to the third intercostal space and each pleural cavity contains 100 ml of hemolyzed bloody fluid.
- Abdomen — the wall contains 2cm thickness of fat and muscle. There is a massive ovarian cyst occupying the entire peritoneal cavity compressing all of the intestines upward and it is the cause for the severe compromise in the respiratory compartments.
- Heart — 340gm. normal
- Lungs — right 960gm, left 760gm
- Uterus and adnexa — Massive left ovarian cyst which occupies the entire peritoneal cavity, compressing all of the organs upward. This mass measures 26 x 20cm in dimension and weighs 3,500gm.
- Nervous system — no significant abnormalities.

This individual was probably not able to sustain oxygen delivery in response to the demand from the exertion of preparing to dive and swimming as well as the associated anxiety. She became hypoxic because of the respiratory compromise, possibly syncopal and drowned.

**DAN Record Number:** 1192 **Birth Year:** 1944 **Sex:** Female
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Anoxic brain damage | 348.1 |
| **Due to:** Near-drowning | 994.1 |
| **Due to:** Recreational scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. History — Morbid obesity | 278.0 |
| 2. S/P stomach plication | 44.69 |
| 3. Organ donor | V59.8 |

The decedent was a 47-year-old obese female, making her final ocean dive for certification as an open-water diver. She was diving with an instructor, and they were returning to shore after completing dive. Decedent was observed floating on her back and then determined to be in cardiac arrest. She was brought to shore and resuscitated by CPR before transfer to the hospital. Her hospital course was steadily down-hill, and she died about 36 hours after the accident.

The autopsy was somewhat limited as heart and other organs were harvested prior to death for transplantation purposes. The brain demonstrated changes consistent with anoxia.

**DAN Record Number:** 1592 **Birth Year:** 1953 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Recreational scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Omphalocele (repaired) | 552.1 |

The decedent was diving offshore and made his entry with snorkel in his mouth instead of regulator despite being advised by companions not to do so. He was in immediate difficulty due to aspiration of sea water. Due to sea conditions rescue was difficult and decedent had submerged several times. He was in cardiac arrest by the time he was returned to the dive vessel.

Although the congenital omphalocoel had been surgically repaired, the decedent had no anterior abdominal wall musculature.

The autopsy was consistent with drowning.

**DAN Record Number:** 1692 **Birth Year:** 1949 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Recreational scuba diving | E910.1 |

Other significant conditions contributing to death but nt resulting in underlying cause

| | |
|---|---|
| 1. Morbid obesity | 278.0 |
| 2. Fatty liver | 571.8 |
| 3. Cardiomegaly | 429.3 |

Decedent was an obese 42-year-old male diving offshore with several companions. He appeared in mild distress before entering water. He entered without his regulator in his mouth and remained afloat a short time. He then was observed to place his regulator in his mouth and descend a few feet (15 to 20). The other divers also descended, but decedent returned to surface. The boat captain threw a line which the

decedent did not take. The boat was then maneuvered so that decedent could be taken aboard. However, the decedent was so large the crew members were unable to lift him aboard even after discarding gear and weight belt. Further assistance eventually arrived, and decedent was transported to shore where he was pronounced dead.

The autopsy findings included 500gm heart, normal coronary arteries, fatty liver and water in sphenoid sinus.

**DAN Record Number:** 3592 **Birth Year:** 1967 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Recreational scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Sarcoidosis | 135 |
| 2. Pulmonary involvement — sarcoid | 517.8 |

There were two people with one set of gear who planned to take turns diving while one remained in the boat. The deceased had been in the water about five to10 minutes when he surfaced screaming for help that he had lost a fin and then submerged. The buddy could not get the boat started and swam to the area where the decedent sank.

A search was made, but the body was not recovered until the next day.

The autopsy findings are consistent with asphyxia due to drowning. There was also extensive pulmonary sarcoidosis.

**DAN Record Number:** 6792 **Birth Year:** 1945 **Sex:** Female
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Recreational scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Exogenous obesity | 250.4 |
| 2. Cholelithiasis | 574.5 |

The decedent was a 47-year-old female diving from a charter boat with friends. The dive was a twilight dive, and she had expressed some hesitation about making dive. She was very obese and had recently had had a bronchial infection.

Unknown difficulties developed at the end of the dive, and the decedent and her companion could not achieve positive buoyancy. The inflator hose to buoyancy compensator was not connected and the weights were integral with the device so that her buddy was not able to release them.

She became unconscious, and her head could not be kept above water. She was placed on the boat with difficulty because of her size. CPR was continued until return to shore, but she was pronounced dead at the local hospital.

The autopsy is consistent with drowning.

# Drowning

## *Drowning Deaths/Physical Barrier Preventing Access to Surface*

The major contribution of entrapment or entanglement as a factor in drowning indicates that many divers do not understand the techniques of diving under a physical barrier preventing immediate access to the surface.

**DAN Record Number:** 4492 **Birth Year:** 1956 **Sex:** Male
**Diver Category:** TD

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Insufficient air | E913.2 |
| **Due to:** Entrapment — shipwreck | E918.1 |
| **Due to:** Scuba diving | E910.1 |

Decedent was wreck diving past 200fsw allegedly using a mixture of 17 percent oxygen, 25 percent helium, and balance nitrogen. His body was found at depth of 206fsw inside the wreck.

The autopsy report is available, and there are no remarkable findings.

**DAN Record Number:** 4792 **Birth Year:** 1969 **Sex:** Male
**Diver Category:** TD

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Insufficient air | E913.2 |
| **Due to:** Entrapment — cave | E918.2 |
| **Due to:** Recreational scuba diving | E910.1 |

The decedent was a certified cave diver with limited experience who with a companion attempted a very difficult cave penetration. He apparently lost contact with the guide line in zero visibility and was unable to find his way out of the cave. The body was not recovered for several days. Autopsy was consistent with drowning.

**DAN Record Number:** 4892 **Birth Year:** 1957 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Entrapment — shipwreck | E918.1 |
| **Due to:** Insufficient air | E913.2 |
| **Due to:** Recreational scuba diving | E910.1 |

Decedent was diving from a charter boat with about 14 divers, but dived without a buddy. The dive was to a freshwater shipwreck at about 90 feet. The decedent was observed to enter the wreck, but did not return to the dive vessel. Limited search was unsuccessful, and the body was recovered the following day by the dive guides on the charter boat. The decedent was sitting in the engine room with gear removed but regulator in mouth. He had apparently prepared to enter a confined space which required removal of gear. It is possible that visibility was lost and decedent simply remained where he was until his air ran out. His equipment including his light was fully functional.

The autopsy was consistent with drowning.

**DAN Record Number:** 5192 **Birth Year:** 1940 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Entanglement — fishing line | E918.5 |
| **Due to:** Scuba diving | E910.1 |

Decedent was an untrained diver with no previous dive experience. He was making a dive in 12 feet of water prior to taking a scuba course. He was not familiar with the equipment — the regulator was reversed on the tank valve, which reversed the usual position of the second stage and probably caused the victim to place it in his mouth upside-down. He was wearing 28 pounds of weight, and the weight belt buckle was covered by the buoyancy compensator (empty when body recovered). His companions reported they last saw him sitting on a log on the bottom then lost him. When recovered he was entangled in monofilament fishing line.

Autopsy consistent with drowning and without significant other findings.

**DAN Record Number:** 8792 **Birth Year:** 1958 **Sex:** Male
and
**DAN Record Number:** 8892 **Birth Year:** 1969 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Insufficient air | E913.2 |
| **Due to:** Entrapment — ice | E918.3 |
| **Due to:** Recreational scuba diving | E910.1 |

Two divers, planning to spearfish, entered a frozen quarry without any of the usual procedures followed by ice divers. No lines, safety divers, or any kind of topside support were utilized. They became lost, ran out of air and drowned.

Autopsy findings compatible with drowning.

**DAN Record Number:** 10492 **Birth Year:** 1966 **Sex:** Male
**Diver Category:** TD

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Entrapment — cave | E918.2 |
| **Due to:** Scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Panic state | 308.0 |

The deceased was an experienced dry cave explorer, but had no training or experience in cave diving, although he had finished a cavern course. He was using borrowed equipment and was not familiar with its use. He and a buddy were at a depth of 75 feet, about 200 feet from the entrance, when problems developed. He had difficulty with buoyancy and air supply, tried to buddy breathe with companion, and then became separated. When the equipment was recovered, tank pressure was about 1,500psi in each of the two tanks, and the regulators were working. There is a statement in the report that a small stick was in the diaphragm of one regulator.

The autopsy is consistent with drowning.

## Drowning Deaths/Insufficient Air

**DAN Record Number:** 6092 **Birth Year:** 1967 **Sex:** Female
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Insufficient air | E913.2 |
| **Due to:** Recreational scuba diving | E910.1 |

The decedent and her companion were participating in check-out dives in approximately 70fsw. The companion who survived had been monitoring air supply of both and indicated to decedent they should ascend when he noted her pressure gauge reading 750psi. The decedent wanted to remain on the bottom to swim to the boat, but both started to ascend. At approximately 20fsw she knocked his mask off and grabbed his primary regulator. In the confusion he aspirated water while attempting to reach his own secondary regulator. He then noted the decedent was no longer using his primary regulator and could not be seen. He surfaced, since he was nearly out of air, and called for help. The boat crew responded and located the decedent at 70fsw about 40 minutes later. CPR was attempted for some time without success.

The dive gear was tested by a local shop with test equipment and was in working order. The tank had been determined to be empty when the rescuers attempted to inflate decedent's buoyancy compensator without success.

The autopsy findings are consistent with drowning. This is an out-of-air fatality resulting from inexperience in monitoring air consumption in 70fsw of cold water.

**DAN Record Number:** 2092 **Birth Year:** 1950 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Insufficient air | E913.2 |
| **Due to:** Scuba diving | E910.1 |

The decedent was ocean diving with two companions. They eventually saw him floating on the surface, but did not investigate until he washed ashore against rocks. At that time he was in cardiac arrest. Equipment investigation disclosed that (1) regulator yoke was loose and leaking badly, (2) tank was empty and contained water, (3) had not been hydrostated for years, (4) and was reversed in back pack, (5) the J valve was up, and (6) there was no submersible pressure gauge.

Autopsy consistent with drowning.

**DAN Record Number:** 9492 **Birth Year:** 1939 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Insufficient air | E913.2 |
| **Due to:** Scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Exogenous obesity | 278.0 |

Deceased was a 250-pound, 67-inch male diving with female companion from a small boat. They surfaced 300 yards down-current from the boat, and the male attempted to swim back underwater. However, he swam in the wrong direction, and the female companion was unable to correct his course. She then noted the decedent floating face-down on the surface. She was not able to rescue him but attracted the attention of nearby fishermen who removed victim to shore.He was pronounced dead on shore by a physician after futile CPR.

The air cylinder was empty. The autopsy report is consistent with drowning. There is no evidence of coronary artery disease.

**DAN Record Number:** 8192 **Birth Year:** 1943 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Insufficient air | E913.2 |
| **Due to:** Scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Left ventricular hypertrophy | 429.3 |
| 2. Fatty liver | 571.8 |

The decedent was diving for lobsters in 75 to 80fsw when he became excited and began to breathe rapidly. His buddies attempted buddy breathing without success. Decedent had a pony bottle, which he did not use. He was assumed to be out of air; equipment, however, was lost during rescue. He was dead on arrival when rescue squad reached scene.

Autopsy disclosed aspiration of large bolus of food into the upper airway, and the pathologist attributes death to this. However, this could have occurred during CPR. The nonspecific pulmonary edema and congestion are consistent with drowning. Of note also is the finding of a moderate to severe fatty liver.

Ethanol was not detected in toxicology study.

**DAN Record Number:** 10392 **Birth Year:** 1955 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Insufficient air | E913.2 |
| **Due to:** Scuba diving | E910.1 |

Deceased was diving in a river with current and depth of about 12 feet. He became separated from his two companions, and they were unable to find him. He was recovered by rescue divers and resuscitation attempted although time underwater without air was lengthy. Deceased was wearing a dry suit with 30 pounds weight in buoyancy compensator compartment, 8 pounds of lead in buoyancy compensator pockets, and 5 pounds of fishing lures, which he had collected on the dive. At recovery, the tank pressure gauge read 200 pounds, although when the tank was checked with another gauge there was no pressure reading. On opening the tank valve there was negligible pressure within the tank.

The autopsy report is consistent with drowning.

The subject evidently ran out of air and was unable to inflate buoyancy compensator. He was not able to reach the surface because of the excessive weight (even for a dry suit).

**DAN Record Number:** 3492 **Birth Year:** 1960 **Sex:** Male
**Diver Category:** TD

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Insufficient air | E913.2 |
| **Due to:** Scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Carbon monoxide 6% saturation | E982.1 |
| 2. Hashimoto's thyroiditis | 245.2 |

Decedent was a recreational amateur technical diver using mixed gas (allegedly 17 percent oxygen, 50 percent helium, remainder nitrogen). He had penetrated a deep wreck and became separated from his companions on leaving the wreck. He was found on the bottom with all tanks empty. He had made previous dives on the same wreck, but never with mixed gas. He was using his breathing mixture to inflate dry suit which may have produced hypothermia.

The source of the carbon monoxide in the pulmonary artery blood is not known. We do not have information on smoking habit.

The autopsy findings were unremarkable.

**DAN Record Number:** 4392 **Birth Year:** 1952 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Insufficient air | E913.2 |
| **Due to:** Scuba diving | E910.1 |

Decedent and buddy had completed an uneventful dive, but surfaced a good distance from their charter boat. Both attempted a surface swim to boat and became separated. The buddy did not realize decedent was in trouble. Decedent was recovered by boat crew from surface, but resuscitation was not possible. Rescuers were unable to inflate his buoyancy compensator, because his cylinder was empty. No mention in the record as to what became of weight belt or its weight.

Decedent had drowned at surface due to inability to maintain positive buoyancy.

The autopsy was consistent with drowning.

## Drowning/Substance Abuse

**DAN Record Number:** 3992 **Birth Year:** 1965 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Postmortem open wound shoulder (alligator bites) | 880.20 |
| 2. Alcohol abuse (0.183gms%) | 305.0 |

This 27-year-old male was an untrained, legally intoxicated individual using borrowed (stolen, according to owner) equipment which was grossly defective and barely functional. He persuaded friends to take him to the center of a flood-stage river with zero visibility where he entered the river (wearing ear plugs). He was not seen again until a few days later when fisherman found his decomposing body lodged in a tree at the river edge.

**DAN Record Number:** 5292 **Birth Year:** 1957 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Alcohol abuse (0.16gm%) | 305.0 |

Decedent was a 35-year-old male reported to have been an alcoholic who made a beach dive after "three or four" beers and subsequently disappeared. His body was recovered two days later. The autopsy was consistent with drowning, and the blood alcohol was 0.16gm%. There are conflicting reports about the condition of the equipment, but he apparently was not wearing flotation, and there was no pressure gauge.

**DAN Record Number:** 7892 **Birth Year:** 1962 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Panic | 308.0 |
| **Due to:** Recreational scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Cannabinoids | E980.3 |

The decedent was a 30-year-old male uncertified diver with limited experience. He was diving with a companion and was using borrowed gear. The buoyancy compensator is reported to have had a broken buckle, and the regulator was apparently in poor condition with deteriorated diaphragms. The decedent developed difficulty at the surface due to aspiration of sea water through the regulator. He could not control buoyancy and fought with his companion who attempted to assist him. He submerged despite efforts of his companion in attempts at rescue. Body was retrieved quickly, but CPR unsuccessful. The autopsy is consistent with drowning.

**DAN Record Number:** 8292 **Birth Year:** 1952 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| 1. Ethanol (110mgm%) brain tissue | 305.0 |
|---|---|

The decedent had completed a night dive and was last seen swimming on the surface returning to the boat. He failed to reach the boat with his group. His body was discovered floating in the ocean several days later.

Autopsy findings were consistent with drowning, and there was a significant ethanol level (110mgm%) in the brain tissue.

## Drowning Deaths/Various Causes

**DAN Record Number:** 1392 **Birth Year:** 1958 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| 1. Panic state | 308.0 |
|---|---|

The decedent was certified as an advanced open-water diver about three months prior to death. He was diving with two companions and was using rented gear. He had some difficulty with the regulator and had returned to the dive shop and replaced it with another. Companions observed decedent ascend to the surface and when they followed were unable to assist because of the decedent's panic. At rescue, the decedent was in cardiac arrest and there was no response to resuscitation. The setting is consistent with air embolism. However, the pathologist did not find any indication of air embolism and final impression was drowning.

**DAN Record Number:** 2192 **Birth Year:** 1971 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Scuba diving | E910.1 |

This is reported to have been an untrained diver using borrowed equipment. The autopsy findings are consistent with drowning. The details of the accident are not reported.

**DAN Record Number:** 2292 **Birth Year:** 1942 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Scuba diving | E910.1 |

Decedent was an accomplished athlete (triathlon) and expert diver for many years. He would dive alone frequently and often made deep dives past 180 to 200 feet. He commonly used oxygen for in-water decompression.

He failed to return from a dive over a deep reef, and his body was recovered floating in the ocean several hours later. His buoyancy compensator was fully inflated. No mention of air cylinders in the report except that they had been removed by U.S.C.G.

The autopsy is consistent with drowning.

**DAN Record Number:** 2592 **Birth Year:** 1978 **Sex:** Female
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Anoxic brain damage | 348.1 |
| **Due to:** Drowning | 994.1 |
| **Due to:** Scuba diving | E910.1 |

Father and 13-year-old daughter were diving in a mountain lake at 4,000 feet elevation and water depth of 84 feet. An unknown problem developed, and both ascended rapidly. The father suffered an immediate fatal air embolism and the decedent daughter had a near drowning episode culminating in death about 18 hours later.

The autopsy findings are consistent with anoxic brain damage.

**DAN Record Number:** 2692 **Birth Year:** 1929 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Scuba diving | E910.1 |

The decedent was a 62-year-old male diving with a family group from a private boat. The group had been spear fishing and the decedent allegedly left the group to return to the boat for another speargun. When he did not return, the group began to search for him. He was found floating facedown in the water without his dive gear. He had apparently placed his dive gear in a dive float made of an inner tube and net bag. The decedent was placed on the boat where attempts at CPR were begun while USCG was notified. The decedent was transported to the hospital where he was pronounced dead. The dive gear was not recovered.

The autopsy findings were essentially unremarkable with the exception of cardiomegaly (590gm). The coronary arteries were described as widely patent.

**DAN Record Number:** 2992 **Birth Year:** 1934 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Migraine headaches | 346.0 |

Decedent developed an unknown problem shortly after beginning dive followed by unconsciousness. Buddy was unable to rescue, but other divers recovered decedent about five minutes later. CPR attempted without success and the diver was DOA at hospital about two hours later.

Decedent had history of migraine headache treated with ergotamine. It is not known if he had recently taken the medication.

**DAN Record Number:** 4692 **Birth Year:** 1963 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Scuba diving | E910.1 |

Decedent was making his first open water ocean dive after certification. He disappeared from buddy's view as they prepared to dive.

Examination of the equipment post mortem revealed the tank to be twisted in the back pack $180^{o}$ so that mouthpiece would barely reach the mouth and the buoyancy compensator would have been difficult to impossible to operate.

The autopsy findings are consistent with drowning.

Decedent had made four previous dives during certification process, but had never made an open water ocean dive.

**DAN Record Number:** 5892 **Birth Year:** 1966 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Anoxic encephalopathy | 348.1 |
| **Due to:** Near-drowning | 994.1 |
| **Due to:** Recreational scuba diving | E910.1 |

Decedent was diving in 30 to 40fsw with a companion and other divers. He returned to the surface with his partner, pulled off his mask, and said words to the effect that his regulator was not working. He then sank out of sight and was not recovered for 10 to 15 minutes. He was resuscitated and transferred to a hospital. He survived five days after the accident.

The regulator was inspected by the beach patrol and reported functioning properly. His cylinder contained 2,500psi.

The autopsy findings were consistent with anoxic encephalopathy as a result of the near-drowning episode.

**DAN Record Number:** 6592 **Birth Year:** 1947 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Scuba diving | E910.1 |

Decedent was a certified beginning diver who had finished certification a few weeks prior to death. He was diving with friends and his dive instructor in tidal water. He lost contact with companions and was observed by onlookers on shore to surface apparently in distress and then sink. The body was recovered by another diver after about a 30-minute search.

Autopsy was unremarkable and consistent with drowning.

**DAN Record Number:** 7292 **Birth Year:** 1965 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Scuba diving | E910.1 |

This diver developed difficulty with his primary regulator at the beginning of the dive and in about 15 feet of water. He was told by the boat captain to switch to secondary (octopus) regulator which he did, but was still noted to be having trouble. The boat captain entered the water and found the decedent unconscious. The decedent was brought aboard the boat, and it was noted that the regulator mouthpiece was in the decedent's mouth but detached from the regulator. The other regulator also did not have a mouthpiece.

The autopsy findings are consistent with drowning.

The difficulty with the regulators suggests that the retaining ties which bind the mouthpiece to the regulators had failed allowing them to separate. This was a death due to equipment defect.

**DAN Record Number:** 9892 **Birth Year:** 1938 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Anoxic brain damage | 348.1 |
| **Due to:** Drowning | 994.1 |
| **Due to:** Scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Heart and liver donor | V59.8 |

Decedent was certified in 1985, with his last dive prior to date of death in January 1992. Accompanied by two experienced friends, he made a 60-foot, 30-minute dive; then a 25-foot, 20-minute dive; and a "bounce" to 52 feet. All three ascended "slowly" together and then began to swim 75 yards to shore. Decedent lagged behind and began flailing arms. When reached he was unconscious, floating face-up. At shore he was pulseless; CPR was started, followed by advanced life support three minutes later. He was transferred to a hyperbaric center, where he received a USN treatment table 6 after initial stabilization. There was no response to treatment. He met the criteria for clinical death and heart and liver were harvested for transplant.

The autopsy was not revealing except for cerebral edema.

## Autopsied Cases - Reports Not Available To DAN

**DAN Record Number:** 7592 **Birth Year:** 1952 **Sex:** Male
**Diver Category:** TD

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Decompression sickness | 993.3 |
| **Due to:** Rapid ascent | E902.2 |
| **Due to:** Scuba diving | E910.1 |

The decedent and his son were wreck diving at 241fsw and had a lengthy decompression commitment. The son apparently developed a problem, and both returned to the surface rapidly without a stop. The decedent died immediately at the surface; the son survived long enough to reach a chamber, where he also died.

Autopsy report not released by authorities.

**DAN Record Number:** 7692 **Birth Year:** 1970 **Sex:** Male
**Diver Category:** TD

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Decompression sickness | 993.3 |
| **Due to:** Rapid ascent | E902.2 |
| **Due to:** Scuba diving | E910.1 |

Decedent and father were diving at 241fsw on a wreck and had acquired decompression obligation estimated at two and one-half hours. The son (decedent) developed a problem of some kind and ascended directly to the surface. The father died immediately and the son survived a few hours and died during recompression treatment.

Autopsy report not released by authorities.

**DAN Record Number:** 8392 **Birth Year:** 1947 **Sex:** Female
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Instantaneous death, cause not discovered | 798.1 |
| **Due to:** Scuba diving | E910.1 |

Two women who were regular dive partners were performing a reef dive. Due to strong current and poor visibility, they immediately became separated. The survivor returned to the surface and attempted to return to the boat, but could not. She states that 30 minutes were required to rescue her. At that time, the decedent was determined to be missing. The body was found about 30 minutes later still wearing weight belt. Very little air had been consumed from the cylinder.

An autopsy was performed, but report is not available.

**DAN Record Number:** 5092 **Birth Year:** 1944 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Ulcerative colitis | 556 |
| 2. Colostomy | V44.3 |
| 3. Asthma | 493.9 |

Decedent was found dead on the surface after about 10 minutes of dive time. He had a colostomy done about five to seven years prior for ulcerative colitis. Asthma developed after the surgery and he had used oral medications and a brochodilator inhaler.

An autopsy was done but the report is not available.

**DAN Record Number:** 6692 **Birth Year:** 1947 **Sex:** F emale
**Diver Category:** R
**Cause of Death:** ICD-9-CM
**Immediate:** Ischemic heart disease 414.0

Other significant conditions contributing to death but not resulting in underlying cause
**Due to:** Scuba diving E910.1

Decedent was U.S. citizen who died in Canada. Newspaper says that autopsy disclosed coronary artery disease as cause of death. We do not have official autopsy report.

**DAN Record Number:** 392 **Birth Year:** 1961 **Sex:** F emale
**Diver Category:** R
**Cause of Death:** ICD-9-CM
**Immediate:** Drowning 994.1
**Due to:** Recreational scuba diving E910.1

Husband and wife were at a resort receiving instruction in an advanced diving course. They were in a group with instructors who swam through a cove, then into a cave, and ultimately into the open ocean. The husband lost his camera and with an instructor spent the rest of the dive looking for it. In the meantime, the wife got into trouble and was assisted by another instructor, who then left her in the care of other divers and returned to his group. The wife was apparently not breathing. The other divers were also students and unable to be of much assistance. The shore was a cliff, and they were unable to make a landing. The group was spotted by a tourist helicopter who notified authorities that a group of divers appeared to be in trouble. Meanwhile, the husband and instructor had finished dive and returned to the hotel, thinking rest of group would be there. Ultimate recovery required the helicopter to airlift the stricken diver from the scene.

Autopsy was done, but reports not available.

**DAN Record Number:** 992 **Birth Year:** 1954 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Not specified | 798.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Scuba diving | E910.1 |

All information comes from newspaper clippings.

Decedent was diving with friends in calm water in the tropics when he disappeared. An immediate search was not successful and the body was located in shallow water the next day. An autopsy was done according to the newspaper articles, and there is speculation in the articles about heart attack and asthma. There is no follow-up information.

Autopsy report is not available.

**DAN Record Number:** 3392 **Birth Year:** 1947 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Insufficient air | E913.2 |
| **Due to:** Scuba diving | E910.1 |

The decedent was low on air at the end of dive and ran out of air on swim back to boat. His buoyancy compensator was not inflated; he switched to his snorkel, apparently aspirated sea water, and drowned.

Autopsy report was not released.

**DAN Record Number:** 2392 **Birth Year:** 1970 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Air embolism | 958.0 |
| **Due to:** Rapid ascent | E902.2 |
| **Due to:** Entanglement (line) | E918.5 |
| **Due to:** Scuba diving | E910.1 |

The deceased was spearfishing around an oil rig. He reportedly speared a large fish, which dragged him until the line fastened to his wrist tangled with the oil rig. Companions later discovered him and were able to free him and take him to the surface. He was probably dead at that time, however. He was air-evacuated to shore hospital, where he was pronounced dead.

Autopsy was done, but local jurisdiction will not release reports.

# Reports Of Cases Not Autopsied

## Bodies Not Recovered

**DAN Record Number:** 192 **Birth Year:** 1935 **Sex:** Male
**Diver Category:** TD
**Cause of Death:** ICD-9-CM
**Immediate:** Death, unspecified cause body not found 799.9
**Due to:** Scuba diving E910.1

Decedent attempted a 275fsw dive at the edge of the Gulf Stream to photograph a sunken barge and reef. He was diving alone from a boat with one person operating the boat. He attempted to place a line on the wreck, but apparently lost the line as it floated free. No trace of the decedent was found despite extensive search over several days. Two divers reached the barge with great difficulty and reported very strong current. They were able to stay only a few minutes.

**DAN Record Number:** 5492 **Birth Year:** 1962 **Sex:** Male
**Diver Category:** R
- and -
**DAN Record Number:** 5592 **Birth Year:** 1961 **Sex:** Male
**Diver Category:** R
**Cause of Death:** ICD-9-CM
**Immediate:** Due to: Death, unspecified cause 799.9
**Due to:** Scuba diving E910.1

Two companions were attempting to set their "personal best" depth record and planned a dive past 200fsw. They failed to return.

**DAN Record Number:** 3692 **Birth Year:** 1954 **Sex:** Male
**Diver Category:** R
**Cause of Death:** ICD-9-CM
**Immediate:** Death, unspecified cause 799.9

Other significant conditions contributing to death but not resulting in underlying cause
1. Recreational scuba diving E910.1

Decedent was lost while diving with a group at a tropical resort. He had no definite buddy and was diving in an area of strong current at edge of wall. Other members of the group had difficulty with current and out-of-air situations. Decedent was last seen near the dive boat, but his companions were having difficulties of their own and did not note the disappearance of the decedent. The body was never found.

**DAN Record Number:** 10592 **Birth Year:** 1959 **Sex:** Male
**Diver Category:** R

| | |
|---|---|
| **Cause of Death:** | ICD-9-CM |
| **Immediate:** Unspecified — body not found | 799.9 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Scuba diving | E910.1 |

All information comes from newspaper clippings. The decedent was diving with a friend and was caught in a strong current. His body was not found.

**DAN Record Number:** 492 **Birth Year:** 1952 **Sex:** Male
**Diver Category:** R

| | |
|---|---|
| **Cause of Death:** | ICD-9-CM |
| **Immediate:** Cause undetermined | 799.9 |
| **Due to:** Scuba diving | E910.1 |

The decedent was captain of a luxury dive vessel which lost its anchor in about 200+fsw. The captain and mate attempted to locate the anchor by diving with a single cylinder each and with an additional cylinder to fill a lift bag. They both failed to surface, and the mate's body was recovered about three weeks later. The decedent's body was not recovered.

**DAN Record Number:** 1992 **Birth Year:** 1965 **Sex:** Female
**Diver Category:** R

| | |
|---|---|
| **Cause of Death:** | ICD-9-CM |
| **Immediate:** Death, unspecified cause | 799.9 |
| **Due to:** Recreational scuba diving | E910.1 |

The decedent was a 27-year-old female spearfishing with one companion. She disappeared from his view and was never seen again. Extensive search failed to locate body or equipment.

**DAN Record Number:** 1792 **Birth Year:** 1960 **Sex:** Male
**Diver Category:** R

| | |
|---|---|
| **Cause of Death:** | ICD-9-CM |
| **Immediate:** Death, cause not determined | 799.9 |
| **Due to:** Nitrogen narcosis | 293.0 |
| **Due to:** Scuba diving | E910.1 |

Decedent made a planned "deep" dive to 130fsw and then kept going. The dive guide attempted to make a rescue, but was also lost. Neither body was recovered.

**DAN Record Number:** 2792 **Birth Year:** 1942 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Death, unspecified cause | 799.9 |
| **Due to:** Scuba diving | E910.1 |

Decedent was diving from charter dive boat offshore on a submarine dating from WWII. Decedent and buddy completed dive on the sub and ascended directly toward the surface to decompress. At about 15fsw, the buddy noted the decedent at 30fsw and descending. He did not appear in difficulty, and the buddy did not follow because of low air supply. The buddy then surfaced and was picked up by the dive boat. Search failed to reveal any sign of the decedent. Several days later the decedent's buoyancy compensator was recovered showing signs of shark bites. The buoyancy compensator was probably damaged postmortem by sharks feeding on the victim.

## Autopsy Not Done

**DAN Record Number:** 7992 **Birth Year:** 1959 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Death, unspecified cause | 798.9 |
| **Due to:** Scuba diving | E910.1 |

Decedent diving with a companion and another buddy team in rough seas. News accounts state that the divers were low or out of air and returned to surface. Decedent was reportedly unconscious and disappeared when companion returned to boat 100 yards away. Companion circled area in boat attempting to find decedent, but could not. USCG rescued the other buddy team.

The body was recovered 10 months later.

**DAN Record Number:** 8492 **Birth Year:** 1952 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Air embolism (suspected) | 958.0 |
| **Due to:** Rapid ascent | E902.2 |
| **Due to:** Scuba diving | E910.1 |

Decedent became unconscious about 10 minutes after a 100-foot dive with a "rapid" ascent. He recovered consciousness briefly, then became unconscious again. He was transported to a chamber *in extremis* and died during the course of treatment. Very little definitive information is available. Autopsy was probably not done.

**DAN Record Number:** 5792 **Birth Year:** 1952 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Cerebral air embolism | 958.0 |
| **Due to:** Rapid ascent | E902.2 |
| **Due to:** Insufficient air | E913.2 |
| **Due to:** Scuba diving | E910.1 |

Newspaper clippings and a report from emergency department nurse are the source of most of the information. The decedent was diving in a quarry at depth of about 45 feet when he apparently ran out of air and made a rapid ascent. He was rescued and resuscitated at the scene. He was then transferred to a hyperbaric facility, where he died a few hours later. We do not have information as to recompression treatment profile. He remained ventilator-dependent and died the following day.

There are two reports that breathing gas was a nitrox mixture.

Autopsy was not done.

**DAN Record Number:** 3092 **Birth Year:** 1942 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Entanglement (line) | E918.5 |
| **Due to:** Recreational scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Hypertension | 401.9 |

This was an inexperienced female diver diving with a group in a quarry at a depth of 100 feet. Another female member of the group developed difficulty on ascent, and the others assisted her. The decedent was determined to be missing when the group with the diver in difficulty reached the surface. The group members were not qualified to search and fortunately did not return to the water. A rescue dive group recovered the body about one hour later. They report that the individual had one leg tangled in a line and that the weight belt was missing. The regulator was out of her mouth, but mask was still on. She had logged in her records a 22-pound weight for her weight belt. Apparently she became entangled, could not ascend, dropped her weight belt, still could not ascend, developed panic and lost her regulator.

Autopsy was not done.

**DAN Record Number:** 6192 **Birth Year:** 1956 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Scuba diving | E910.1 |

The decedent was diving alone in a quarry and failed to return home. His wife found the body floating in the quarry. The cause of death was listed as freshwater drowning. There was no autopsy.

**DAN Record Number:** 8592 **Birth Year:** NA **Sex:** Male
**Diver Category:** TD

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Insufficient air | E913.2 |
| **Due to:** Entrapment (cave) | E918.2 |
| **Due to:** Scuba diving | E910.1 |

The deceased was a fully certified cave diver who became lost in a side passage during a cave dive to 150 feet. He was unable to find his way out and ran out of air.

Autopsy was not done.

**DAN Record Number:** 3792 **Birth Year:** 1964 **Sex:** Male
**Diver Category:** TD

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Seizure | 780.3 |
| **Due to:** Oxygen toxicity | 987.7 |
| **Due to:** Scuba diving | E910.1 |

Decedent was cave diving using a nitrogen oxygen mixture consisting of 39 percent oxygen and the balance nitrogen. According to our limited information he had a seizure at depth and could not be rescued by his companion. The analysis with the report concludes that the $PO_2$ at the maximum depth achieved was 1.42 atmospheres. This $PO_2$ could produce a seizure.

Autopsy was not done.

**DAN Record Number:** 3292 **Birth Year:** 1936 **Sex:** Female
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Anoxic brain damage | 348.1 |
| **Due to:** Drowning | 994.1 |
| **Due to:** Scuba diving | E910.1 |

This female student diver was on check-out dive with her instructor when she developed difficulty at about 25 feet. The instructor brought her to surface, where she was in respiratory arrest. Mouth-to-mouth resuscitation was started in the water. She received CPR and advanced life support on shore and apparently was in ventricular fibrillation on arrival at hospital emergency department. She was

resuscitated, eventually transferred to a hospital with a monoplace chamber, and treated with U.S. Navy treatment table 6. There was no response to treatment, and she remained unresponsive and ventilator-dependent. Support was discontinued.

No autopsy was done.

**DAN Record Number:** 10292 **Birth Year:** 1954 **Sex:** Female
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Entrapment-between rocks | E918.9 |
| **Due to**: Scuba diving | E910.1 |

Information is limited to a newspaper clipping. Decedent and husband, who operated a marina and RV park, were on a private cruise aboard their own trimaran.

The decedent had completed a dive with a companion and was sitting on a rock when a large wave knocked her down, pinning her between two rocks. The companion was unable to free decedent, and by the time she obtained help the decedent had drifted away. When recovered, attempts at resuscitation were unsuccessful.

Autopsy was not done.

**DAN Record Number:** 5392 **Birth Year:** 1966 **Sex:** Female
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Insufficient air | E913.2 |
| **Due to:** Recreational scuba diving | E910.1 |

The decedent had completed a basic diving course and was certified as open-water diver about three weeks prior to death. Her certification did not include night diving or training in night diving.
She began a night dive with friends shortly after 2300 hours on a summer night. She was using borrowed equipment and was a member of a three-diver buddy team. Maximum depth on her computer was 65 feet, bottom time approximately 20 minutes and water temperature was 51$^{0}$F. Ascent started when pressure gauges were 300 to 500psi. The three buddies lost sight of each other on ascent.

At the surface Buddy 3 was out of the water, and the victim did not appear. Buddy 2 stepped out of water on a ledge and looked for light or bubbles. Another buddy team surfaced with a bright light. Buddy 2 thought the victim was with them, but when they were close enough to communicate he learned that she was not. The other team dove and immediately located the victim, but could not raise her. The victim's buddies returned to the bottom and found her at 59 feet. She was brought to surface and CPR begun.

The first rescue unit arrived on scene about 15 to 20 minutes later. On initial evaluation decedent was pulseless and apneic. EKG monitor showed asystole. She was intubated and received advanced life support en route to hospital where she was DOA.

She was wearing a quarter-inch farmer john wetsuit with hood, gloves, and a buoyancy compensator. The weight belt was 20 pounds. Her tank pressure gauge was reading near zero when examined after recovery.

Decedent was novice diver with only one 30-minute dive since completing her certification. She was not trained in night diving and did not have adequate experience to attempt a night dive. She was over-weighted by about 10 pounds which increased the difficulty of her dive. Her equipment was borrowed so that she was not completely familiar with it. It is also possible that she was out of air on ascent and could not inflate buoyancy compensator enough to overcome the excess weight she was wearing. Again, she did not think to release weight belt.

The end result of out-of-air situation and drowning arose from all the above factors.

An autopsy was not done.

**DAN Record Number:** 5992 **Birth Year:** 1961 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Anoxic brain damage | 348.1 |
| **Due to:** Drowning | 994.1 |
| **Due to:** Scuba diving | E910.1 |

Decedent was found in 10 to 12fsw with mask and weight belt on, but not wearing tank or regulator. The tank and regulator were lying on bottom near him. He was resuscitated and transported to hospital, where he survived about 48 hours.

An autopsy was not done.

**DAN Record Number:** 6492 **Birth Year:** 1945 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Ischemic heart disease | 414.0 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Scuba diving | E910.1 |

We have very little information and most of that from newspaper clippings. Autopsy was not done due to objection by family.

**DAN Record Number:** 1292 **Birth Year:** 1937 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Acute myocardial infarction | 410.9 |
| **Due to:** Coronary atherosclerosis | 414.0 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Scuba diving | E910.1 |

The diver had a history of a previous myocardial infarction. He had completed a dive with no apparent problems and was on the boat removing gear when he developed chest pain which progressed to cardiac arrest. CPR was attempted without success.

Autopsy was not done.

**DAN Record Number:** 1892 **Birth Year:** 1967 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Insufficient air | E913.2 |
| **Due to:** Scuba diving | E910.1 |

This diver had recovered a weight belt at the end of a dive and was attempting to carry it to the surface. He apparently ran out of air and attempted buddy breathing using buddy's primary regulator. Both got into difficulty; and decedent could not be rescued by the buddy, who nearly drowned.

Autopsy was not done

**DAN Record Number:** 592 **Birth Year:** 1964 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Cause undetermined | 798.9 |
| **Due to:** Scuba Diving | E910.1 |

Decedent was mate on a luxury dive vessel which lost its anchor while attempting to anchor in about 200fsw. Deceased and captain attempted to recover the anchor wearing a single cylinder each with a spare for inflating a lift bag. Both disappeared and the decedent's body was found about three weeks later. The captain's body was never found.

No autopsy was done.

**DAN Record Number:** 7792 **Birth Year:** 1960 **Sex:** Female
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Scuba diving | E910.1 |

Information comes from newspaper clippings and interview with a diver who was at the scene, but not involved in the dive. Diver was inexperienced diver using borrowed equipment. The report suggests that diver had difficulty operating the inflator button on the buoyancy compensator and was holding the deflate button open rather than the inflate button.

Autopsy was not done.

**DAN Record Number:** 7492 **Birth Year:** 1970 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Entrapment cave | E918.2 |
| **Due to:** Insufficient air | E913.2 |
| **Due to:** Scuba diving | E910.1 |

Other significant conditions contributing to death but not resulting in underlying cause

| | |
|---|---|
| 1. Cannabinoids | E980.3 |
| 2. Ethanol (blood 0.03g/dl) | 305.0 |

Autopsy was not done, but forensic investigation was limited to blood and urine toxicology.

Sheriff report states that decedent and companion consumed three beers each in the two hours before their dive. During the dive the decedent's dive companion developed a problem with his power inflator which became disconnected from the buoyancy compensator. The decedent apparently attempted to assist by buddy breathing before they separated. The buddy managed to ascend and was assisted before surfacing by another dive party. The decedent apparently did not replace his own regulator in his mouth and may have lost consciousness from hypoxia. When last seen by his companion, the decedent was sinking back into the spring. When found, the regulator was out of the mouth and the tank contained 2,100psi.

**DAN Record Number:** 10192 **Birth Year:** 1939 **Sex:** Male
**Diver Category:** R

| **Cause of Death:** | ICD-9-CM |
|---|---|
| **Immediate:** Drowning | 994.1 |
| **Due to:** Recreational scuba diving | E910.1 |

The only information we have comes from newspaper articles. Decedent had been diving with relatives and friends. As he tried to climb up on the rocky shore following his dive, he fell back into the water. He was found underwater 25 minutes later by his companions. Authorities said he may have had a heart

attack or seizure after he surfaced, preventing him from climbing out of the water. No autopsy was done, and the death was ruled an accident.

**DAN Record Number:** 4592
No information is available except a location, name and date of death.

**DAN Record Number:** 7092
No information is available except a location, name and date of death.

The following case is included because of the time relationship to diving. It is not included as a diving accident.

**DAN Record Number:** 10092 **Birth Year:** 1951 **Sex:** Male
**Diver Category:** R
**Cause of Death:** ICD-9-CM
**Immediate:** Aortic aneurysm — dissection 441.0

Decedent had made uneventful dives at a tropical resort on day prior to death reaching depths of 80 to 100 feet on first dive and 40 feet on second dive. Times were well within table limits. Dives were finished in late morning. He spent the afternoon on the beach and consumed several soft drinks. Five hours after the dive chest pain developed which became worse and was associated with numbness in arms. He was transferred to hospital, where he was found to be slightly confused, but pain had diminished. There was a differential in blood pressure between left and right arms; lower on the left. He required narcotic during the night and developed cardiac arrest about 6 a.m. Autopsy disclosed dissection of aorta involving aortic valve and extending to femoral artery.

There is a strong family history for dissecting aortic aneurysm with five members of immediate family having died of same disease.

The role of the day's activity, including diving, in the timing of the final event is speculative.

# DAN

# DIVING DECOMPRESSION ILLNESS REPORTING FORM

**This reporting form is entirely confidential. This is not an insurance claim form.** Send form to: **Divers Alert Network**, Box 3823, Duke University Medical Center, Durham, North Carolina 27710

**DATE & TIME OF ACCIDENT**
MONTH/DAY/YEAR
Time _____ AM PM

**IS THIS A FATALITY REPORT?**
☐ YES ☐ NO

**For DAN Office Use Only**
CASE
SEVERITY CODE
BMI

**1. PATIENT NAME** LAST FIRST MI

**2. OCCUPATION**

**3. ADDRESS** STREET CITY ST ZIP

**4. PATIENT PHONE (HOME)** - -

**5. PATIENT PHONE (WORK)** - -

**6. COUNTRY (IF NOT USA)**

**7. AGE** YRS

**8. SEX** M or F

**9. HEIGHT** FT IN

**10. WEIGHT** LBS.

**11. CERTIFYING AGENCY**
A - PADI
B - NAUI
C - NASDS
D - YMCA
E - SSI
F - Other
G - None

**12. CERTIFICATION LEVEL**
A - Basic
B - Open Water
C - Advanced
D - Divemaster
E - Instructor
F - Commercial
G - Other
H - None
I - Student

**13. DAN MEMBER?**
Y - Yes
N - No

**14. YEARS DIVING** YEARS MONTHS

**15. NUMBER OF DIVES MADE** Total; Previous 12 months

**16. PREVIOUS DIVE ACCIDENTS**
A - Possible DCS
B - DCS
C - AGE
D - Pul. barotrauma
E - None

**17. CURRENT MEDICATIONS**
Y or N
Prescription
Non-prescription
List _____

**18. CIGARETTE USE**
A - Presently
B - In past
C - Never
Years Smoking
Packs per day

**19. PREVIOUS MAJOR ILLNESSES/ SURGERY**
(Provide up to 3 responses)
A - Chest-lung
B - Asthma
C - Chest-heart
D - Gastrointestinal/Abdomen
E - Brain
F - Spine/Back
G - Limb or joint of DCS site
H - Circulation/Blood
I - Neurologic/Nervous system
J - Muscle/Skeleton system
K - Eye
L - Mental/Emotional
M - Other _____
N - None

Past:
A - 2-6 months
B - 7-12 months
C - 1-3 years
D - 2-5 years
E - 6+ years

List and describe specific problems:

**20. CURRENT HEALTH PROBLEMS WITHIN PREVIOUS 2 MONTH**
(Provide up to 3 responses)
A - Chest-lung
B - Asthma
C - Chest-heart
D - Gastrointestinal/Abdomen
E - Brain
F - Spine/Back
G - Limb or joint of DCS site
H - Circulation/Blood
I - Neurologic/Nervous system
J - Muscle/Skeleton system
K - Eye
L - Mental/Emotional
M - Other _____
N - None

List and describe specific problems or additional current medications

PLEASE ATTACH SEPARATE SHEET FOR ADDITIONAL INFORMATION OR NARRATIVE.

I understand that the information in this form will be used for research purposes only, and that all personal information will be kept strictly **confidential**. I also understand that the Divers Alert Network may need to contact me in the future for clarification of information provided on this form.

_____
Patient Signature

# DIVE ACCIDENT

**21. PURPOSE OF DIVE**
- A - Pleasure
- B - Work/Labor

**22. DIVE ACTIVITY** (up to 2 responses)
- A - Wreck
- B - Cave
- C - Night
- D - Photography
- E - Under Instruction
- F - Providing Instruction
- G - Spearfishing/ Game collecting
- H - Sightseeing

**23. ENVIRONMENT**
- A - Freshwater
- B - Saltwater

**24. ALTITUDE OF DIVE**
- A - Sea Level
- B - > Sea Level but < 1000 ft.
- C - > 1000 ft.

**25. Was this dive or dive series typical of your normal type of diving?**
- Y - Yes
- N - No

IF NO, Explain _____

**26. DIVER'S PERCEPTION OF TEMPERATURE**
- A - Cold
- B - Hot
- C - Comfortable

**27. CURRENT STRENGTH**
- A - Strong
- B - Moderate
- C - Mild
- D - None

**28. AIR SUPPLY**
- A - Scuba Air
- B - Surface Supply Air
- C - Mixed gas
- D - None/Breath-hold dive

**29. AIR CONSUMPTION**
- A - Ran low
- B - Out of air
- C - Not a problem
- D - Buddy breathing (not octopus)

**30. BUOYANCY PROBLEM**
- Y - Yes
- N - No

**31. RAPID ASCENT**
- Y - Yes
- N - No

**32. WITHIN LIMITS-Y or N**
- Tables (which table _____ )
- or
- Computer (type _____ )

**33. TYPE OF SUIT**
- A - Wet
- B - Partial Wet
- C - Dry
- D - Lycra
- E - Swim

**34. EQUIPMENT USED ON DIVE:** (please check all that apply)
- Depth gauge
- Timing device/watch
- Buoyancy vest
- BC Inflator hose in use
- Decompression computer

**35. EQUIPMENT MALFUNCTION:**
- A - None
- B - Regulator
- C - BC Vest
- D - Weight belt
- E - Dry suit
- F - DC Computer
- G - Inflator hose
- H - Contaminated air supply
- I - Equipment was not familiar to you.
- J - Other

Reason: _____

**36. TYPE OF DIVE**
- Y - Yes
- N - No
- Single
- Repetitive

**37. WOMEN, PLEASE RESPOND** (up to 2 responses)

When the accident occurred, were you:
- A - Menstruating
- B - On birth control medication
- C - Pregnant
- D - None of the above

**38. DIVE LOCATION:**

State, Province, or Island: _____

Country or nearest country: _____

**39. How long ago was your last Dive Trip/Series?**

Circle one: Days Weeks Months

**40. STRENUOUS EXCERCISE**
- Y - Yes
- N - No
- 24 hours predive
- During dive
- 6 hours postdive

**41. PREDIVE HEALTH**
- A - Nausea/ vomiting
- B - Hangover
- C - Diarrhea
- D - Other
- E - No Problem

**42. ALCOHOL**

Please check:

| | Number of drinks, beers, or wine |
|---|---|
| None | |
| Night Before | |
| Predive | |
| Between Dives | |
| Post Dive | |

**43. RECREATIONAL DRUG USE**

Prior to, between, or after dive
- Y - Yes
- N - No

**44. Do you consider yourself physically fit?**
- Y - Yes
- N - No

Do you excercise on a weekly basis? (Y or N)

# Days per week

**45. FATIGUE OR LACK OF SLEEP PRIOR TO DIVE?**
- Y - Yes
- N - No

**46. DIVE SERIES**

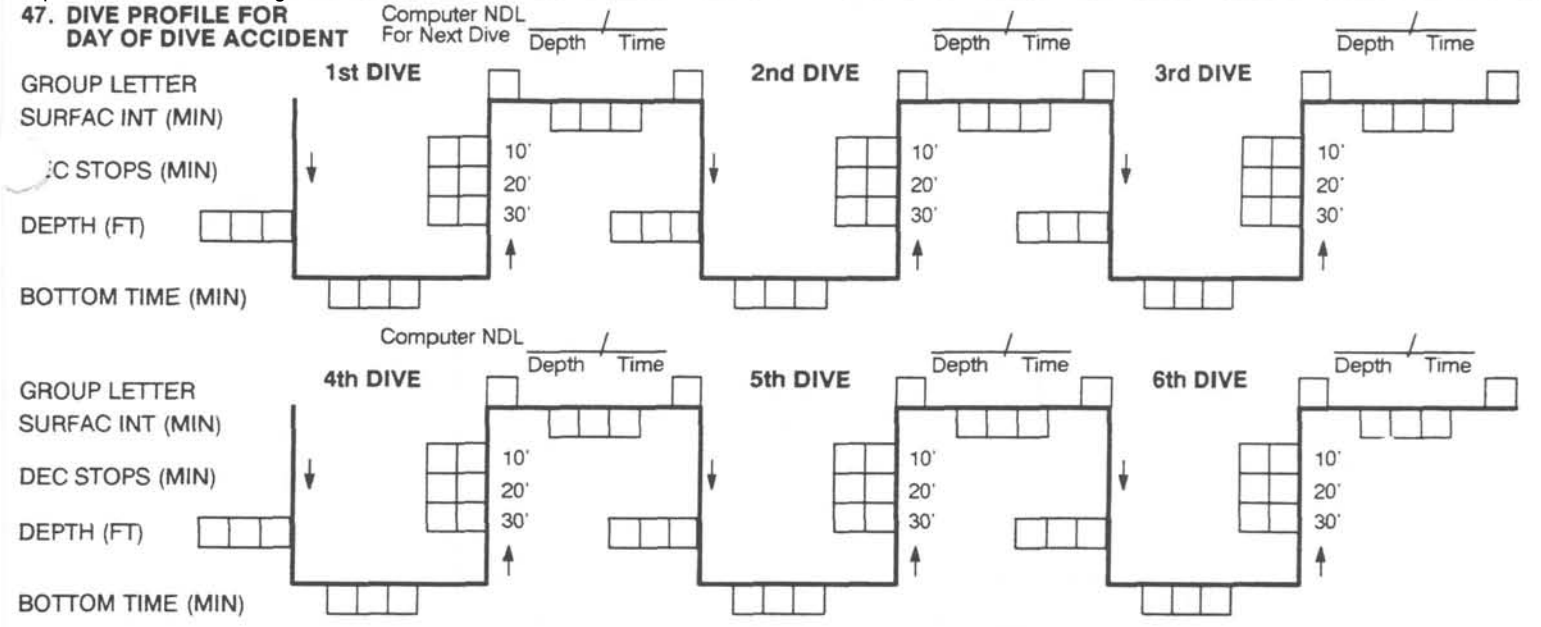
Please fill in all that apply up to and including your last dive. If you skipped a day please leave that day blank.

| | DAY 1 | DAY 2 | DAY 3 | DAY 4 | DAY 5 | DAY 6 | DAY 7 |
|---|---|---|---|---|---|---|---|
| Total # of dives | | | | | | | |
| Any night dive? (How many) | | | | | | | |
| Any symptoms? (Yor N) | | | | | | | |
| A - All no stop dive(s)<br>B - Any safety stop<br>C - Any dive requiring decompression stops | | | | | | | |
| A - Multilevel (time divided)<br>B - Square | | | | | | | |
| Deepest Dive (ft.) | | | | | | | |

# DIVE ACCIDENT (cont.)



**47. DIVE PROFILE FOR DAY OF DIVE ACCIDENT**




## PRE-CHAMBER INFORMATION

**48. INITIAL CONTACT WAS:**

- A – DAN Emergency
- B – DAN Non-emergency
- C – Hospital emergency room
- D – Emergency medical service
- E – US Coast Guard
- F – Physician
- G – Dive instructor/shop
- H – Other: _____

**49. Total delay from symptom onset to contacting DAN or other medical help:**

HOURS or DAYS

**50. FLYING OR INCREASED ELEVATION AFTER DIVING AND PRIOR TO TREATMENT?**

- A – Commercial airliner
- B – Unpressurized aircraft
- C – Med Evac Flight
- D – Mountain elevation
- E – Does not apply

Hours post dive (flew or went into elevation)

elevation (in feet)

**SIGNS & SYMPTONS**

1st Symptom / 2nd Symptom / 3rd Symptom / 4th Symptom / 5th Symptom / 6th Symptom

- A – Pain
- B – Rash
- C – Itching
- D – Weakness
- E – Numbness/Tingling
- F – Dizziness/Vertigo
- G – Semi-consciousness
- H – Unconsciousness
- I – Restlessness
- J – Extreme fatigue
- K – Visual disturbance
- L – Speech disturbance
- M – **Headache**
- N – Paralysis
- O – Difficulty breathing
- P – Nausea/Vomiting
- Q – Hemoptosis/coughing blood from lungs
- R – Muscle twitching
- S – Convulsions
- T – Hearing loss
- U – Ringing ears
- V – Decreased skin sensation
- W – Bladder problem
- X – Bowel problem
- Y – Personality change
- Z – Difficulty walking/ standing
- 1 – Reflex change
- 2 – Other: _____

**52. LOCATION:** Block A = location of symptom
Then please check ( ✓ )
L = Left R = Right B = Bilateral/Both Sides

1st Symptom / 2nd Symptom / 3rd Symptom / 4th Symptom / 5th Symptom / 6th Symptom

A L R B

- A – Head
- B – Face
- C – Sinus
- D – Eyes
- E – Ears
- F – Neck
- G – Shoulder
- H – Entire arm
- I – Upper arm
- J – Elbow
- K – Forearm
- L – Wrist
- M – Hand
- N – Fingers
- O – Chest
- P – Back
- Q – Upper back
- R – Lower back
- S – Abdomen
- T – Buttock
- U – Groin
- V – Hip
- W – Entire leg
- X – Thigh
- Y – Knee
- Z – Calf
- 1 – Shin
- 2 – Ankle
- 3 – Foot
- 4 – Toes
- 5 – Trunk
- 6 – Generalized
- 7 – Other: _____

**53. SYMPTOM ONSET:**

| | HOURS | MINUTES | or | BEFORE SURFACING FROM DIVE |
|---|---|---|---|---|
| 1st Symptom | | | | |
| 2nd Symptom | | | | |
| 3rd Symptom | | | | |
| 4th Symptom | | | | |
| 5th Symptom | | | | |
| 6th Symptom | | | | |

**54. ANY OF THE SYMPTOMS FROM #51 PRIOR TO THE LAST DIVE?**

Y – Yes
N – No

If yes, which symptoms?

1st / 2nd / 3rd / 4th / 5th / 6th

Other

Explain: _____

**55. FIRST AID ADMINISTERED BEFORE HOSPITAL OR CHAMBER HELP WAS RECEIVED?**

Y – Yes
N – No

- Oxygen
- Aspirin
- Oral fluids
- Head down position/ Trendelenburg

If oxygen was received was delivery by:

- A – Demand valve
- B – Freeflow valve
- C – Don't know

# PRE-CHAMBER INFORMATION (cont.)

**56. HOSPITAL TREATMENT ADMINISTERED**

(Please check all that apply):

- ☐ None
- ☐ Oral fluids
- ☐ IV fluids
- ☐ Oxygen
- ☐ Steroids
- ☐ Anticoagulant
- ☐ Aspirin
- ☐ Other medication

_____

_____

**57. RELIEF BEFORE CHAMBER TREATMENT?**

☐

A - Complete
B - Partial
C - Temporary
D - None

**59. PRE-CHAMBER RELIEF OCCURRED:**

☐

A - Without first aid or medical care
B - Following first aid
C - Following pre-chamber hospital care
D - No relief occurred

**58. IF ANY RELIEF OCCURRED, WHICH SYMPTOMS FROM #51 ABOVE?**

(Please check):

- 1st ☐
- 2nd ☐
- 3rd ☐
- 4th ☐
- 5th ☐
- 6th ☐

# CHAMBER TREATMENT

**60. CHAMBER TREATMENT FACILITY LOCATION**

CITY

STATE COUNTRY

Date & Time of Treatment

MONTH/DAY/YEAR

Time _____ AM PM

Name of hyperbaric facility:

Treating doctor

Form Completed By

_____

**61. TYPE OF CHAMBER**
(please check)

| Initial Treatment | Retreatment Chamber |
|---|---|
| ☐ Monoplace | ☐ Monoplace |
| ☐ Dualplace | ☐ Dualplace |
| ☐ Multiplace | ☐ Multiplace |
| ☐ No chamber treatment given | |

**62. TOTAL DELAY FROM SYMPTOM ONSET TO RECOMPRESSION**

HOURS or DAYS

**63. INITIAL TREATMENT**

☐

A - USN TT4
B - USN TT5
C - USN TT6
D - USN TT6A
E - HART Protocol
F - KINDWALL Protocol
G - 45 fsw 90 min
H - 33 fsw 120 min
I - Other

_____

_____

**64. TABLE EXTENSIONS REQUIRED?**

☐

Y - Yes
N - No

**65. RELIEF AFTER INITIAL TREATMENT OF SYMPTOMS FROM # 51?**

- 1st ☐
- 2nd ☐
- 3rd ☐
- 4th ☐
- 5th ☐
- 6th ☐

Please indicate:

A - Complete
B - Partial
C - Temporary
D - None

**66. RETREATMENT GIVEN**
(Provide up to 3 responses)

| TABLE | NUMBER OF TREATMENTS |
|---|---|
| ☐ | ☐ |
| ☐ | ☐ |
| ☐ | ☐ |

A - USN TT4
B - USN TT5
C - USN TT6
D - USN TT6A
E - HART Protocol
F - KINDWALL Protocol
G - 45 fsw 90 min
H - 33 fsw 120 min
I - Other

_____

**67. RELIEF AFTER HYPERBARIC THERAPY COMPLETED?**

☐

A - Complete
B - Partial
C - Temporary
D - Hyperbaric therapy not completed
E - None

**68. RESIDUAL SYMPTOMS AFTER HYPERBARIC THERAPY COMPLETED?**

☐

A - Pain only
B - Neurologic
C - Hyperbaric therapy not completed
D - None

**69. DURATION OF RESIDUAL SYMPTOMS**

(Circle one)

☐

DAYS
WEEKS
MONTHS

**70. FINAL DIAGNOSIS:**

☐

A - DCS I
B - DCS II
C - Air Embolism
D - Pulmonary Barotrauma
O - Other

_____

_____

_____

**I WOULD LIKE TO RECEIVE DAN INFORMATION.**

☐

Y - Yes
N - No

# Diving Fatality Reporting Form

**This reporting form is entirely confidential. This is not an insurance claim form.** Send form to:
**Divers Alert Network,** Box 3823, Duke University Medical Center, Durham, North Carolina 27710
**Fatality Research** (919) 684-2948

*DAN research use only:*

DAN CN _____ — _____ Source 1 _____ Source 2 _____ Source 3 _____ Source 4 _____
ME CN _____ First Contact _____
IA CN _____ Telephone ____ — (____) — ____ — _____
Diver classification _____ Region _____

***Diver Information***

**Date / time of accident** _____
**Date / time of death** _____
**Accident location** _____
**County** _____ **State** _____ **Country** _____
**Death location** _____
**County** _____ **State** _____ **Country** _____
**Name of deceased** _____ _____ _____
*last* *first* *middle*
**Occupation** _____
**Date of birth** _____
**Age** _____ **Sex** *(please circle)* Male Female **Race** _____
**Height** *(please circle)* _____ feet & inches centimeters **Weight** *(please circle)* _____ pounds kilograms
**Marital status** _____ **Next of kin** _____ **Relationship** _____
**Next of kin telephone** _____ — (_____) — _____ — _____

***Diver Experience***

**Certified** *(please circle)* Yes No
**Certifying agency** *(please circle)* BSAC CMAS NASDS NAUI PADI PDIC SSI YMCA None
Other _____
**Certification level** *(please circle)* Open Water Open Water I Open Water II Advanced Rescue Divemaster
Instructor Assistant Instructor Commercial Other _____ None Student
**Number of years diving** _____ years _____ months
**Total lifetime dives made** _____ **Number of dives made in past year** _____
**Time since last dive series** _____ days _____ months _____ years
**General experience level** *(please circle)* Non-certified Novice (0 to 5 dives) Inexperienced (6 to 20 dives)
Intermediate (21 to 40 dives) Advanced (41 to 60 dives) Experienced (61+ dives)
**Experience level with activity / environment** *(please circle)* Non-certified Novice (0 to 5 dives)
Inexperienced (6 to 20 dives) Intermediate (21 to 40 dives) Advanced (41 to 60 dives) Experienced (61+ dives)

***Diver Health***

**Previous major illness** _____ **When** _____ years _____ months
**Current health problems** _____
**Undiagnosed health problems** _____
**Current Medications** *Prescription (please circle)* Yes No *(please list)* _____
*Nonprescription (please circle)* Yes No *(please list)* _____
**Previous dive accidents** *(please circle)* Yes No *(please list)* _____
**Physically fit** *(please circle)* Yes No **Regular exercise** *(please circle)* Yes No

**Cigarette use** *(please circle)* Have never smoked Have smoked in past Presently smoke
Years smoking _____ Packs per day _____
**Predive health** *(please circle)* Nausea Hangover Diarrhea Predive alcohol No problem
Other _____
**Influences at accident time** *(please circle)* Alcohol Recreational drugs None
**Mental status** *(please circle)* Stressed Anxious Quiet Agitated Talkative Depressed No problem
Other _____
**Fatigue** *(please circle)* Yes No

***Dive Conditions***

**Type of water entry** *(please circle)* Shore Private boat Charter boat Pool
Other _____
**Altitude of dive** *(please circle)* Sea level (below 1,000 feet) Greater than 1,000 but less than 3,000 feet
Greater than 3,000 feet
**Water environment** *(please circle)* Saltwater Freshwater
**Water temperature** _____ °F °C **Water depth** _____ feet
**Seas** _____ **Visibility** _____ feet
**Surge** _____ **Current** *(please circle)* None Mild Moderate Strong
**Bottom type** _____
**Weather conditions** *(describe)* _____ **Air temperature** _____ °F °C
**Overhead environment** *(please circle)* Yes No
*(if yes, please circle)* Cavern Cave Ice Wreck penetration
Other _____
**Diver's first time at location** *(please circle)* Yes No **Surface observer** *(please circle)* Yes No
**Surface tender** *(please circle)* Yes No

***Dive Profile***

**Dive activity** *(please circle)*

| | *Primary* | *Secondary* |
|---|---|---|
| | Wreck (no penetration) | Wreck (no penetration) |
| | Wreck (penetration) | Wreck (penetration) |
| | Cave | Cave |
| | Cavern | Cavern |
| | Night | Night |
| | Ice | Ice |
| | Photography | Photography |
| | Under instruction | Under instruction |
| | Providing instruction | Providing instruction |
| | Spearfishing / game collection | Spearfishing / game collection |
| | Pleasure / sightseeing | Pleasure / sightseeing |
| | Work / task; commercial; deep dive | Work / task; commercial; deep dive |
| | Other _____ | Other _____ |

**Specialty dive** *(please circle)* Yes No **Specialty certified** *(please circle)* Yes No
**Buddy** *(please circle)* Yes No **Buddy separation** *(please circle)* Yes No
**Number in buddy team** _____ **Number in dive party** _____
**Single dive** *(please circle)* Yes No **Decompression dive** *(please circle)* Yes No
**Nitrogen narcosis** *(please circle)* Yes No **Lost** *(please circle)* Yes No
**Trapped** *(please circle)* Yes No **Entangled** *(please circle)* Yes No

| **Dive profile** | Dive 1 | Dive 2 | Dive 3 |
|---|---|---|---|
| Depth (feet) | _____ | _____ | _____ |
| Bottom time (min) | _____ | _____ | _____ |
| Surface interval (hours / min) | _____:_____ | _____:_____ | _____:_____ |
| | hours : min | hours : min | hours : min |

### *Dive Equipment & Problems*

**Familiar with equipment** *(please circle)* Yes No

**Equipment source** *(please circle)* Borrowed Rented Owned

**Dive computer** *(please circle)* Yes No

| *Computer* | *Model* | *Computer* | *Model* |
|---|---|---|---|
| Beuchat | _____ | Scubapro | _____ |
| Dacor | _____ | Sherwood | _____ |
| Mares | _____ | Suunto | _____ |
| Oceanic | _____ | Tekna | _____ |
| Orca | _____ | U.S. Divers | _____ |
| Parkway | _____ | Other | _____ |
| | | Unknown | _____ |

**Exposure suit** *(please circle)* Wet Partial wet Dry Lycra Swim None Other _____

**Air supply** *(please circle)* Scuba Surface-supplied Mixed-gas scuba Mixed-gas surface Breathhold diving Rebreather Bad air supply

**Air tested** *(please circle)* Yes No

**Air consumption** *(please circle)* Not a problem Low on air Out of air Buddy breathing / sharing air

**Weight belt** _____ lbs **Weight belt dropped** *(please circle)* Yes No

**Buoyancy problem** *(please circle)* Yes No **Rapid ascent** *(please circle)* Yes No

**Infrequent diver** *(please circle)* Yes No **Equipment problems** *(please circle)* Yes No

**List problems** (1) _____ (2) _____ (3) _____

### *Recovery & First Aid*

**Was event witnessed** *(please circle)* Yes No **By whom** _____

**How long into the dive did the problem occur** _____ *(minutes)* _____ *(feet)*

**When problem occurred** *(please circle)* Surface pre-dive Immediately Early dive Mid-dive Late dive Post-dive Unobserved

**Where problem occurred** *(please circle)* Surface pre-dive Descent Ascent Surface post-dive Unobserved

**Signs of diver in distress** *(please circle)* Yes No **Panic** *(please circle)* Yes No

**Immediate search** *(please circle)* Yes No

**If no, after** _____ *(days)* _____ *(hours)* _____ *(minutes)*

**Body recovered** *(please circle)* Yes No

**If yes, after** _____ *(days)* _____ *(hours)* _____ *(minutes)*

**CPR done** *(please circle)* Yes No Not applicable

**Oxygen available** *(please circle)* Yes No **Oxygen administered** *(please circle)* Yes No Not applicable

**USCG** *(please circle)* Yes No **Medevac** *(please circle)* Yes No

### *Emergency Treatment*

**Hospital** _____

**Location** *(city, state, country)* _____

**Contact** _____

**Telephone** _____ — (_____) —_____ — _____

**Hyperbaric treatment** *(please circle)* Yes No

**Type of chamber** *(please circle)* Monoplace Dualplace Multiplace

**Attending physician** _____

**Hospital treatment including hyperbaric treatment**

_____

_____

_____

_____

_____

***Investigative Report***

**Agency** *(please circle)* Police Sheriff USCG Other

**Investigator / Contact** _____

**Telephone** _____ — (_____) — _____ — _____

**Accident scenario** _____

_____

_____

_____

_____

***Medical Examiner Report***

**Medical Examiner's name** _____ **Coroner's name** _____

**Address** *(street, city, state, zip, country)*

_____

_____

**Place death was registered** _____

**Probable cause of death** _____

Due to 1 _____

Due to 2 _____

Due to 3 _____

Due to 4 _____

Due to 5 _____

**Contributing condition(s)**

1 _____

2 _____

3 _____

4 _____

**Manner of death** *(please circle)* Natural Accident Homicide Suicide Pending

**Autopsy done** *(please circle)* Yes No

**Organ donor** *(please circle)* Yes No Other

**Organs harvested** *(please list)*

_____

_____

***Individual Submitting This Report***

**Name** _____ **Daytime Telephone Number** _____ — (_____) — _____ — _____

**Address** *(street, city, state, zip, country)*

_____

_____

I understand that the information in this form will be used for research purposes only and that all personal information will be kept strictly confidential. I also understand that Divers Alert Network may need to contact me in the future for clarification of information provided on this form.

**Signature** _____

**Diving Emergencies** (919) 684-8111 • **Medical/Safety Information** (919) 684-2948 • **FAX** (919) 493-3040

# Appendix D - Fatality Location Tables

## U.S. Fatalities from 1970 to 1992 in Foreign Areas

| Country | 1970-1979 | 1980-1989 | 1990-1991 | 1992 | Country Totals |
|---|---|---|---|---|---|
| Anguilla | | 1 | | | 1 |
| Antigua | | 1 | | | 1 |
| Aruba | 1 | | | | 1 |
| Australia | 1 | 2 | | | 3 |
| Bahamas | 17 | 19 | 6 | | 42 |
| Barbados | | 2 | | | 2 |
| Bequia | | | 1 | | 1 |
| Bermuda | 1 | 1 | 1 | | 3 |
| Belize | 2 | 4 | 1 | | 7 |
| Bonaire | | | 1 | 1 | 2 |
| British Virgin Islands | | 4 | | | 4 |
| Canada | 7 | 6 | | 1 | 14 |
| Caribbean Area | 27 | | | 2 | 29 |
| Cayman Islands | 3 | 5 | 1 | 1 | 10 |
| Central America | 1 | | | | 1 |
| Costa Rica | | 1 | | | 1 |
| Cuba | | 2 | | | 2 |
| Dominica | | | 1 | | 1 |
| Egypt | | | 1 | | 1 |
| Fiji Islands | | 2 | | | 2 |
| French Antilles | | 2 | | | 2 |
| Greece | 3 | 1 | | | 4 |
| Honduras | | 2 | 1 | | 3 |
| Italy | | | 2 | | 2 |
| Jamaica | | | 2 | 1 | 3 |
| Malaysia | | 1 | | | 1 |
| Martinique | | 1 | 1 | | 2 |
| Mediterranean Area | 2 | | | | 2 |
| Mexico | 18 | 28 | 9 | 6 | 61 |
| Micronesia | | | 1 | | 1 |
| Morocco | | 1 | | | 1 |
| Netherlands Antilles | | 2 | | | 2 |
| New Caledonia | | 1 | | | 1 |
| Okinawa | 11 | 3 | 2 | | 16 |
| Palau | | | 1 | | 1 |
| Panama | | | 1 | | 1 |
| Philippines | | 2 | | | 2 |
| Portugal | | 1 | | | 1 |
| Red Sea | | 3 | | | 3 |
| St. Martin | | | 1 | | 1 |
| St Vincent/Grenadines | | 4 | | | 4 |
| Saipan | | 1 | | 1 | 2 |
| Thailand | | 1 | | | 1 |
| Saudi Arabia | | 2 | | | 2 |
| Unknown | | 1 | | | 1 |
| **Decade Totals** | **94** | **107** | **34** | **13** | **248** |

# U.S. Fatalities from 1970 to 1992 by State

| State | 1970-1979 | 1980-1989 | 1990-1991 | 1992 | State Totals |
|---|---|---|---|---|---|
| Alabama | 4 | 2 | | 1 | 7 |
| Alaska | 9 | 9 | | 2 | 20 |
| Arizona | 2 | 4 | | | 6 |
| Arkansas | 5 | 8 | | 1 | 14 |
| California | 262 | 155 | 24 | 15 | 456 |
| Colorado | 4 | | | | 4 |
| Connecticut | 9 | 9 | 1 | | 19 |
| Delaware | | 3 | 1 | | 4 |
| Florida | 297 | 231 | 36 | 22 | 586 |
| Georgia | 9 | 11 | 1 | | 21 |
| Hawaii | 63 | 54 | 6 | 2 | 125 |
| Idaho | 2 | 4 | | | 6 |
| Illinois | 10 | 3 | 1 | | 14 |
| Indiana | 6 | 1 | 1 | | 8 |
| Iowa | 3 | | | 2 | 5 |
| Kansas | 1 | | | | 1 |
| Kentucky | 3 | 1 | | | 4 |
| Louisiana | 6 | 5 | 1 | 2 | 14 |
| Maine | 17 | 8 | 4 | 1 | 30 |
| Maryland | 9 | 1 | | | 10 |
| Massachusetts | 39 | 32 | 2 | 3 | 76 |
| Michigan | 33 | 12 | 1 | 1 | 47 |
| Minnesota | 5 | 4 | 1 | | 10 |
| Mississippi | 1 | 3 | | | 4 |
| Missouri | 18 | 3 | 2 | 3 | 26 |
| Montana | | 2 | 1 | | 3 |
| Nebraska | 4 | 5 | | | 9 |
| Nevada | 4 | 2 | 1 | | 7 |
| New Hampshire | 4 | 4 | | | 8 |
| New Jersey | 25 | 15 | 6 | 5 | 51 |
| New Mexico | 6 | 4 | 1 | 1 | 12 |
| New York | 38 | 21 | 5 | 5 | 69 |
| North Carolina | 8 | 12 | 1 | 2 | 23 |
| Ohio | 9 | 6 | 1 | 1 | 17 |
| Oklahoma | 2 | 1 | | | 3 |
| Oregon | 15 | 11 | 2 | | 28 |
| Pennsylvania | 7 | 7 | 6 | 4 | 24 |
| Rhode Island | 11 | 19 | 2 | 2 | 34 |
| South Carolina | 7 | 3 | | | 10 |
| South Dakota | 1 | | 1 | | 2 |
| Tennessee | 5 | 4 | 2 | | 11 |
| Texas | 32 | 19 | 3 | 1 | 55 |
| Utah | 14 | 5 | 1 | | 20 |
| Vermont | 2 | 1 | | | 3 |
| Virginia | 9 | 5 | | | 14 |
| Washington | 96 | 67 | 5 | 3 | 171 |
| West Virginia | 1 | | | 1 | 2 |
| Wisconsin | 20 | 10 | 2 | 1 | 33 |
| Wyoming | | 2 | | | 2 |
| Washington DC | 1 | | | | 1 |
| **Decade Totals** | **1138** | **788** | **122** | **81** | **2129** |

## U.S. Fatalities from 1970 to 1992 by U.S. Territory

| U.S. Territory | 1970-1979 | 1980-1989 | 1990-1991 | 1992 | Territory Totals |
|---|---|---|---|---|---|
| Guam | 1 | | | | 1 |
| Marshall Island | 1 | | | | 1 |
| Puerto Rico | 4 | 5 | 1 | | 10 |
| Virgin Islands | 1 | 11 | 1 | 2 | 15 |
| **Decade Totals** | **7** | **16** | **2** | **2** | **27** |

# Appendix E
# Fatal Diving Accident Investigation

**G. Yancey Mebane** M.D.
*Associate Medical Director, Director EMS Training, Divers Alert Network*

The forensic pathologist is usually able to determine a cause of death based on the findings of the autopsy. This cause is usually expressed as a diagnosis of a disease or a pathophysiological event. However, we are interested in the factors which led up to the final event, and this requires investigation of the total incident.

**Personal and Past Medical History**

A most important part of this investigation is knowledge of the divers' personal characteristics and past medical history. Does the diver meet the standards for physical fitness? No matter what the nature of the accident, being unfit will lessen the chances of survival. The diver should be in a state of physical training consistent with the dive and should have no medical condition that might be aggravated by the effects of pressure or hard physical work.

Pre-existing diseases may predispose to the diving accident. Emotional instability and respiratory infections are particularly important. Medical screening of new divers to detect the presence of physical disqualifications should be required. Adequate initial training followed by further training to match the conditions of the dive is essential. Open ocean, wreck, cold-water and other special diving situations require training beyond initial "open-water" certification issued by training agencies. A diver who completes an open water certification is not a finished product but is now ready to learn the skills required for special situations such as the open ocean, currents, cold water, limited visibility and others.

The diver certainly should have adequate training for the conditions of the dive. Much criticism is currently directed at some programs which certify after a superficial level of training. Other divers tend to enter specific areas of diving without specialized training. As an example, consider cave diving, wreck diving, or ice diving, which require special techniques and equipment. Some recreational divers are now experimenting with mixed-gas diving, dives past 200 feet, and self-treatment with oxygen in the water. There have been fatalities due to amateurish attempts at mixed-gas diving and also with dives past 200 feet. The diver must be trained to at least the depth of his dive with the equipment he is to use and for the environmental conditions he will encounter.

Past diving accident history should be taken into consideration. Some disorders experienced by divers in the past are likely to be repeated under similar conditions.

These may include:
1. Breath-hold after hyperventilation
2. Panic with hyperventilation
3. Pulmonary barotrauma
4. Nitrogen narcosis

5. Syncope of ascent
6. DCS -- especially involving the spinal cord
7. Oxygen toxicity
8. Alcohol and drug history

**Environmental Conditions**

The weather and environmental conditions at the time of the accident are important. Many fatalities are associated with adverse environmental conditions. The diver may be exposed to increased risk during entry and exit as well as during the dive by any of these factors. A diver swimming against a 1-knot current is at his limit and probably consuming 2 liters or more of oxygen per minute and ventilating 40 liters of gas per minute per atmosphere pressure. It is practically impossible for a diver to make headway against a 2-knot current.

The temperature of the water will influence hypothermia, decompression sickness and the function of various pieces of diving equipment. Regulators may cease to function when the temperature is at the freezing point. Limited or zero visibility may contribute to the progression of a fatal diving accident following a minor problem.

Entrapment or entanglement is common as a cause of death and includes the diver lost in a cave, wreck or under ice. There have also been open water deaths due to entanglement in lines and kelp. Accidents involving marine animals are very rare.

**Dive Profile and History**

Essential information includes the location, bottom time and depth of the incident dive as well as recent dives prior to the final dive. The speed of ascent and stops is important information as well as a report of the dive plan. Was there one? Was it followed? Why not?

The degree of physical exertion required by the dive is important to know as the diver unable to meet the physical requirements of the dive is at great risk. All of this is crucial information but often is not available because the divers did not make observations or did not record details.

**Diving Equipment**

The equipment should be impounded after an accident until a detailed written report can be completed and photographs are taken. The cause of the accident may become apparent with examination of the equipment. The equipment may have been affected by the accident. There may have been loss or displacement of movable items or damage to protective clothing. Gas spaces such as face mask or buoyancy vest may be flooded. Look for vomitus on the mouthpiece or equipment.

The weight belt should be carefully examined and weighed. Determine if it was or could be released. Record the presence or absence of watch, depth gauge, submersible pressure gauge, decompression meter and knife. Record the condition of the buoyancy compensator.

The regulator and cylinder should be examined for defects and the final tank pressure recorded. Samples of the gas within the cylinder should be analyzed for correct partial pressures and the presence of toxic substances.

# Appendix F
# Autopsy Protocol for Victims of Scuba Diving Accidents

**Eric P. Kindwall** M.D.
*Associate Professor, Department of Plastic and Reconstructive Surgery, Director of Hyperbaric Medicine, Medical College of Wisconsin.*

**Jorge Pellegrini** M.D.
Associate Pathologist, Department of Pathology, St. Luke's Hospital, Milwaukee.

The purpose of this protocol is to assist the pathologist in establishing immediate cause of sudden death in the water. In a pressure-related diving accident, the traumatic agent is a simple gas which, although causing death, is evanescent and may go undetected using the standard autopsy routine. Cerebral air embolism has often been inadvertently signed out as simple drowning. It is important to remember that cerebral air embolism can occur in water depths as little as 1.12 meters (four feet) and can produce fatal results within less than one minute of surfacing. Postmortem bubbles often confuse the issue. This protocol should be filed for future use when performing an autopsy on a scuba diver.

## Introduction

Since the advent of civilian sport scuba diving (self-contained underwater breathing apparatus) as a major recreational pastime, diving accidents have inevitably increased and of necessity, pathologists with little previous knowledge of diving, are called upon to perform autopsies when accidents cause fatality. This poses difficult problems as there have been no protocols widely disseminated for use by pathologists in carrying out these highly specialized postmortem examinations. The purpose of this protocol is to assist the pathologist in establishing the immediate cause of sudden death in the water, and little emphasis is given to long-term or chronic changes associated with decompression accidents.

In a pressure-related diving accident, the traumatic agent is a simple gas or mixture of gases which although causing death, is evanescent and very well may go undetected when the standard autopsy routine is followed. As a result, many cases of cerebral air embolism have been inadvertently signed out as simple drowning. It is important to remember that cerebral air embolism can occur in water depths as little as 1.12 meters (four feet) and may produce fatal results within a minute or two of surfacing.

Sometimes bubbles are found in blood vessels at autopsy tempting the pathologist to diagnose "bends" or decompression sickness as the cause of death when in reality the bubbles were formed postmortem. With a good understanding of the mechanisms involved and knowledge of a proper autopsy technique, much more accurate assessment of the cause of death can be made.

This protocol should be filed for future use when performing an autopsy on anyone who has died while wearing a scuba apparatus or for that matter, any type of compressed air diving apparatus. This would even include a bucket worn over the head under water supplied with air from a garden hose and tire pump.

**Diagnoses to Consider**

Aside from obvious trauma such as propeller injury or a natural illness such as stroke or myocardial infarction, the scuba diver is most likely to suffer:

1. Cerebral air embolism with or without mediastinal emphysema and pneumothorax[2]. Drowning.
3. Decompression sickness.
4. Bites or stings from venomous marine animals.

The pathologic findings in drowning will not be considered here as they are covered in standard reference works.

**Cerebral Air Embolism**

The mechanism of arterial gas embolism hinges on the fact that while using a compressed air scuba apparatus the air pressure in the lungs at depth is in equilibrium at all times with the pressure of the water surrounding the diver so long as he breathes normally. Thus it is greater than atmospheric. If the diver, through carelessness or in a panic, ascends only a few feet holding his breath, the air in the lungs expands as water pressure decreases, and forces its way through alveolar walls. Dog experiments have shown that a trans-pulmonic pressure of 80 mm Hg is enough to rupture the alveoli[3]. This 80 mm pressure differential between the intra-tracheal pressure and the intra-pleural pressure corresponds to a change in sea water pressure of a little more than one meter (four feet). After passing out of the alveoli, the air may migrate medially producing pneumomediastinum and in some cases pneumopericardium or it may rupture a bleb on the pleural surface causing pneumothorax, though this latter tends to be rare. The worst situation which can commonly occur is that air enters the pulmonary capillaries and is carried via the pulmonary veins to the left heart. From there it is pumped directly into the brain. Scuba tanks are filled with compressed air, never oxygen which becomes too toxic at depth, so resultant arterial bubble contain mostly nitrogen. Air embolism will produce air bubbles in the meningeal and cerebral arteries and possibly in the coronaries. However, because the diver invariably embolizes in a head up position while vertically ascending through the water, mesenteric, spinal cord and the vertebral arteries and bones are seldom involved.

It must be emphasized that this event cannot take place if the swimmer is simply breath-hold diving. The victim must have been breathing air at greater than normal pressure under water using some kind of breathing apparatus or appliance.

Because sudden death occurring in the family swimming pool while using scuba gear is not easily attributable to the scuba itself in the minds of most people, the possibility of gas embolism is often overlooked. Again, experiments have demonstrated that as little as 0.4 ml of blood-air foam delivered to the right spot in the brain stem may produce death. In the clinical situation, when death does not immediately ensue, the patient often enters the emergency room with the signs and the symptoms of having suffered a cerebro-vascular accident. This can mistakenly be attributed to ruptured berry aneurysm or some other vascular catastrophe. As a rule of thumb, anyone dying while using scuba apparatus should be considered to have suffered an air embolism as the initiating event until proved otherwise.

**Pathologic Findings in Air Embolism**

1. Intra-arterial and intra-arteriolar air bubbles in the brain and meningeal vessels, with possible petechial hemorrhages in the white and gray matter.
2. Ruptured alveoli or acute pulmonary emphysema on microscopic examination. This is often hard to document because of sectioning artifact causing tears of alveolar walls.
3. Grossly hemorrhagic lungs.
4. Possible voids due to air bubbles in the capillaries surrounding the alveoli.
5. Ring and ball hemorrhages in the brain.
6. Signs of acute right heart failure. The heart, if it contains air, may float when surrounded by water.
7. Passive congestion of the kidneys.
8. Liebermeister's sign (white mottling of the dorsum of the tongue).
9. Air bubbles in the retinal and coronary arteries.
10. Mediastinal emphysema.
11. Pneumo-pericardium.
12. Subcutaneous emphysema above the clavicles to the angle of the jaw (should be palpable).
13. Pneumothorax.

It would be unusual to find changes such as softening of neural tissue, changes in Ammon's horn and gliosis because air embolism usually causes nearly instant death. If the patient survives the immediate insult, he usually does not die although he may remain severely crippled as a late result of air embolism blocking the vascular supply with its secondary consequences.

**Decompression Sickness or Bends**

When a diver breathes air under increased pressure, nitrogen from the air goes into physical solution in his blood and tissues. This causes him no difficulty while on the bottom, (aside from an increasing narcotizing effect as he exceeds 30 meters (100 feet) in depth. However, if he has dived deeper than 10 meters (33 feet) and has remained for a long enough time to absorb significant amounts of nitrogen, gas bubbles are formed in his tissues and capillaries as nitrogen comes out of solution if he returns rapidly to the surface. Nitrogen bubbles of themselves can block circulation, tear neural tissue and also initiate complex biochemical changes causing platelet aggregation, agglutination of formed elements of the blood, sludging, stasis infarction and shock. Symptoms range from pain to paresthesias, paralysis (usually the middle third of the spinal cord), asphyxia (as pulmonary capillaries are blocked), shock and death. It is important to remember that decompression sickness (especially producing fatality) *is unlikely to occur unless* the diver has been at a depth *in excess of 10 meters (33 feet).* The time required to absorb damaging amounts of nitrogen varies inversely with depth. For example, one can spend up to 200 minutes at 12 meters (40 feet) and come directly to the surface without pausing on the way for decompression stops. However, this time is reduced to 25 minutes at 30 meters (100 feet) and only five minutes at 50 meters (165 feet). Bottom time is reckoned as the time between leaving the surface and leaving the bottom. Normal ascent rate is never more than 18 meters (60 feet) per minute.[5] Assuming the diver has made a safe dive, whether requiring decompression stops on ascent or not, when he arrives on the surface he will still have more than normal amounts of nitrogen in his tissues. This will slowly be lost over the next 12 to 24 hours. Should he make another dive within that time, he must take into account the residual nitrogen present in his body at the beginning of the second dive. This will be additive to the nitrogen absorbed on the second dive, and he must shorten his second dive or lengthen his decompression time in accordance with the length of the surface interval between the dives.

There are special U.S. Navy repetitive dive decompression tables for use in calculating length of stay or decompression requirements for repetitive dives within 12 hours.[5] Repetitive diving is a frequent cause of decompression sickness in sport divers either because they miscalculate or fail to observe any decompression rules.

All of the above has relevance to the pathologist as it demonstrates that greater than normal amounts of nitrogen are present in the diver's body even during safe dives. If the diver should die from any cause either on the bottom or within 12 to 24 hours of the dive, nitrogen will cease being carried from the tissues and eliminated through the lungs. Therefore, it will gradually revert to gas phase *in situ* producing *post-mortem* bubbles which, in such cases, will have no bearing on the cause of death. Postmortem nitrogen bubble formation, however, will be minimal or absent if the victim has died during or following short exposures to depths of less than 10 meters.

The obvious pathological findings in someone dying acutely of decompression sickness can only appear as bubbles consisting mostly of nitrogen in any tissue of the body. These bubbles usually originate on the *venous* side but when blood pressure disappears, bubbles will merge even on the arterial side. During life, the blood pressure in the arteries tends to prevent bubble formation except in cases of almost explosive decompression. The lesser pressure present in the veins permits the earlier appearance of bubbles and indeed, during normal, safe and asymptomatic decompression so-called "silent" bubbles can be detected frequently with Doppler sonar over the vena cava. In decompression sickness as already discussed, the bubble will usually represent postmortem bubble formation and therefore, cannot reliably be used to certify the cause of death to be due to too rapid decompression. This is always true if the patient died while under pressure in a recompression chamber or died after spending some time at depth with subsequent recovery of the body from the bottom. The clinical history must invariably be relied upon to establish cause of death in cases of decompression sickness. Following acute death from massive decompression sickness, such as explosive decompression, there will not have been time for tissue reaction such as gliosis, etc., to take place. The pathologist's task in such cases will be to differentiate between air embolism and decompression sickness as the immediate cause of death. In other cases where death is not immediate, the history and clinical course will amply serve to establish the cause of death. Prominent will be lesions in the white matter of the middle third of the spinal cord with evidence of stasis infarction. The brain is usually spared except in cases of aviation decompression sickness[2].

**Venomous stings or bites from marine animals**

1. A bite or sting on any part of the body.
2. Unexplained edema on any part of the body.
3. Pathologic change consistent with anaphylaxis or other strong allergic reaction.

In marine animal stings the history is often suggestive, but the body should be examined very carefully to detect lesions that might have gone unsuspected. Occasionally, a relatively minor bite or sting may precipitate panic or incapacitation which subsequently leads to death by embolism or drowning. A point to keep in mind, however, is that some marine animal bites may take place after death. In such cases, tissue reaction will not occur as compared to bites occurring antemortem.

It is important to remember that in *all* pressure-related diving accidents, the presence of bubbles formed *postmortem* may tend to cloud and confuse the pathologic diagnosis. The length of time which passes between death and the autopsy as well as the amount of body tissue decomposition which takes place requires that the pathologist exercise good judgment in coming to his final conclusions as well as careful performance of the autopsy which includes an analysis of the gases found.

**Preliminary Preparation for the Autopsy**

1. Obtain a history from the referring physician, rescue squad and/or the victim's diving companions. This will alert the pathologist as to what he must include or may omit in his consideration of the autopsy findings. Determine the dive profile(s), whether or not the victim dropped his weight belt, inflated his vest, etc. If possible, the diving rig or scuba apparatus should be recovered and retained for future examination. Such examination would include presence of blood or vomit in the regulator or hoses, the amount of air left in the tank(s) and an analysis of the air for contaminants such as carbon monoxide or oil; whether or not the regulator functions properly, its breathing resistance, etc., the status and operability of the life vest, depth gauge, reserve air gauge, position of the J valve and the status and function of the buoyancy compensator if one was used. An expert familiar with scuba equipment should assist with such examination.
2. X-ray the head, neck, thorax and abdomen of the victim for soft tissue detail (free air) as well as bone injury.
3. Prepare a number of tight fitting, well greased 10 cc syringes equipped with three-way stopcocks and long spinal needles.
4. Obtain a 50 cc graduate and fill a deep sink in the autopsy room with water.
5. Provide a hose to the autopsy table so that a gentle stream of water may be directed into the area being examined. Notify the laboratory that you wish to have gas samples analyzed for oxygen and carbon dioxide. (Nitrogen content of the gases may be obtained by subtraction.)

**The Autopsy**

Inspect the body carefully for signs of trauma or other unusual lesions. Do not forget to look at the back. Palpate the area above the clavicles and below the angles of the jaw for signs of subcutaneous emphysema.

Make an incision through the full thickness of the skin down the midline of the sternum beginning at the second intercostal space. Continue the incision down to the origin of the xyphoid process.[4] Secondly, make two transverse incisions at the ends of the initial vertical incision carrying them laterad a couple of centimeters. Apply towel clips to the skin edges and using blunt and sharp dissection, undermine the skin laterad. Two assistants then "tent up" the skin, and the resultant compartment created above the chest wall fills with water. The 50 cc graduate is then completely filled with water in the deep sink, inverted with the palm or a cork occluding the open end, is brought over to the victim and the occluded end immersed in the compartment of water over the sternum. An 18-gauge needle is then inserted into the pleural space at the level of the second intercostal space. The open end of the graduate should be positioned directly above the needle so that any gas issuing from the pleural space is trapped in the graduate. The amount of gas recovered is recorded. Then, with the bottom of the graduate again occluded, it is brought over to the deep sink, and a 10 cc syringe with a long spinal needle is inserted in the graduate so that the gas may be withdrawn for analysis. Before the syringe is removed from the water,

the stopcock is closed. Should it be impossible to reach the gas pocket at the top of the graduate, the gas may be transferred to a 50 cc beaker, previously filled completely with water in the deep sink by upending the graduate underneath the inverted beaker. Gas may then be withdrawn from the beaker. If the water is warm and this maneuver is carried out rapidly, there will be little absorption of $CO_2$. Repeat the process on the other side.

The sternum is then transected at the level of the second intercostal space, and the ribs are divided just medial to the costochondral junction. The section of ribs and sternum is removed.

Observe as one goes along whether or not bubbles issue from the cut ends of any vessels. This applies throughout the autopsy. The vessels should be identified if possible as to whether they are arteries or veins. The water in the compartment formed by this skin "tent" will probably become discolored by blood making it opaque. If discrete blood leakage points can be identified, they may be cross-clamped. As the field becomes opaque, fresh water is introduced with the hose to retain visibility. The pericardial sac is opened under water after is has been determined whether or not pneumopericardium is present. A needle is then inserted into the right and left ventricles in turn again in a flooded field with the inverted graduate held over the needle so that the escaping gas may be trapped, the amount recorded and the gas analyzed.

As the mediastinal structures are dissected, note carefully the presence or absence of gas in each discrete compartment as it is opened, bubbles being apparent as they rise through the water. Dissection should be meticulous as if a major vessel is entered early, the field will become too opaque. The hose can be used to flush the blood out to produce a clear field. When the mediastinum, heart and major vessels have been examined under water for the presence of air, the water may be evacuated from the thoracic cavity, and the autopsy proceeds in the conventional manner. Carefully examine the lungs for signs of bullae or emphysematous blebs or hemorrhage (gross or petechial). Carefully check individual lobes or bronchopulmonary segments for evidence of bronchial obstruction which might have given rise to blockage of the affected area during decompression such as mucous plugs, broncholiths, foreign bodies, etc. Obtain blood, urine and bile samples for analysis for alcohol or other drugs.

Be sure to probe the heart for evidence of inter-atrial or inter-ventricular septal defect. As the autopsy proceeds, note if there are signs of venous congestion compatible with right sided heat failure. In a case of air embolism where autopsy takes place soon after death, and *before* postmortem bubble formation has taken place, the right ventricle should not contain gas unless there is an inter-atrial septal defect. Gas in the heart, present only in the left ventricle is pathognomonic of arterial air embolism which in the scuba diver becomes cerebral air embolism. If the victim has made a short shallow dive and has suffered air embolism, the left ventricle should contain gas with an oxygen content approaching 16 percent. If bubbles are found after a dive of a long duration or there has been considerable time lag between death and autopsy, the gas bubbles in the heart will be predominantly nitrogen or $CO_2$, respectively or both.

## Head

Ideally, it would be best if the entire autopsy could be carried out under water, but this is not practical as when major vessels are opened, the water becomes impossibly opaque.

Before opening the head, tie all of the vessels in the neck so as to preclude the entrance of air into the cerebral or meningeal vessels from below.

After careful examination of the head and neck, the scalp is reflected and the calvarium removed with a saw, as is customary. As the calvarium is removed, bubbles may appear as artifacts in the superficial veins or venous sinuses. These can safely be disregarded[1]. The arteries of the meninges should be examined for the presence of gas and then after exposing the brain, gas bubbles should be looked for in the surface vessels. The frontal lobes are reflected back and after the optic nerves have been cut, carefully examine the Circle of Willis for bubbles. Air appearing here is particularly significant. The middle cerebral arteries are also examined in situ by carefully spreading the insula. Photograph any bubbles found[1]. The brain is then removed and fixed.

## Interpreting Results

The presence or absence of gas in any organ following a scuba diving death can never be conclusive evidence of decompression sickness. With the exception of the case where air is found only in the left ventricle (but not in the right) and in cerebral arteries (but not veins), air embolism cannot be diagnosed simply by the presence of bubbles. However, under certain circumstances gas analysis of the intracardiac air can be revealing. If there is a difference in the oxygen content of gases obtained from the right and left sides of the heart, with more oxygen being present on the left, one can only come to the conclusion that air was introduced traumatically into the arterial circulation. Postmortem bubbles contain little, if any, oxygen, and the same is true for decompression sickness bubbles. When taken in context with the circumstances of the dive and other information which may be provided to the pathologist, gas analysis can help to establish a diagnosis.

In summary, if the basic mechanisms of air embolism, decompression sickness, mediastinal emphysema and pneumothorax stemming from scuba diving are understood by the pathologist, the results of the careful autopsy may often be able to distinguish between a pressure related mechanism of death and simple drowning. The same is true for the potentially fatal consequences of venomous animal sting.

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# Appendix G
# Occupational Diving Fatalities

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During 1992, a total of 14 occupational diving fatalities were reported. An analysis and scenario for each case is presented by category as established by NUADC in agreement with the National Oceanic and Atmospheric Administration (NOAA), the Occupational Safety and Health Administration (OSHA) and the U.S. Coast Guard (U.S.C.G.). A description of all 13 categories is presented at the end of this report.

In Category C-I, we recorded one fatality in the Gulf of Mexico. This 29-year-old male was excavating with a hand jet in about 30 feet of water when his band mask was apparently blown off. He made a panic ascent to the surface and suffered a massive embolism.

Four deaths were recorded in Category C-II. In the first case a 37-year-old male died of asphyxia as the result of an alleged malfunction of his breathing air system while repairing a valve in 60 feet of water in a nuclear power plant.

A 21-year-old male diver died in a filtration tank of a recreational water park. It was reported that he had been working in the tank with scuba gear when he resurfaced due to air problems. While his partner left to obtain more air he apparently reentered the tank using only a mask.

A double fatality Category C-II event occurred during a lake dive. An 18-year-old male and a 28-year-old male who only held recreational diving certifications, entered the ice-covered lake to place a pipe cap on an underwater discharge pipe. Though tethered together, the victims had no safety line to the exit hole and failed to use surface tenders. They became lost and drowned due to a lack of air. They had no prior experience in occupational diving.

Two deaths were reported in Category C-III. In the first case a 29-year-old diver succumbed while doing a hull inspection on a ship. Two other nearby divers working on a pier discovered the body.

A 28-year-old male died in an ice-covered lake in Michigan in January while working on the underside of a pleasure craft. He was not using a tender nor did he have any safety line to the surface. He became lost under the ice and ran out of air.

Three fatalities were recorded in the marine harvesting industry, Category C-IV. All three divers were engaged in sea urchin harvesting. There were two in the state of Maine and one in California. The two fatalities in Maine occurred in June and December and involved a 23- and 28-year-old male respectively. Both were using scuba gear and both exhibited their distress by surfacing and calling for help. In the first case, the victim was recovered within minutes, while in the December case the recovery took more than three hours.

In the third fatality, the individual was a 46-year-old veteran diver with more than 20 years' experience. He was operating with a surface-supplied-air system, close to shore and in heavy waves when he lost his urchin bag. In attempting to retrieve the bag, he disconnected his air hose and entered the surf zone, where he was overcome by surging waves. The victim drowned despite heroic efforts by his partner, who swam to him and brought him back to the boat.

Two cases of occupational diving fatalities in 1992 have been assigned to Category C-VII. This is a miscellaneous category for those deaths which do not meet the specifications for any of the other 12 categories. Both of these deaths took place while the victims were retrieving golf balls from ponds.

The first victim, a 47-year-old male, while using a surface-supplied air system in 12 feet of water. It was reported that he was wearing more than 80 pounds of weight to help him stay on the bottom and had acquired more than 70 pounds of golf balls which were tied to his waist. Upon surfacing he took off his face mask and yelled for help. It took more than 15 minutes to recover the body. The victim had been doing this sort of work for more than five years.

A 29-year-old male was using borrowed scuba equipment when he got into trouble while diving for golf balls. An associate attempted a rescue but nearly drowned himself because of the victim's struggling and the heavy weight of more than 300 golf balls attached to the victim in a net bag. Later, a rope was tied to the victim to allow dragging him to shore. The victim lay unconscious in a hospital for 11 days before expiring.

In Category C-H, we recorded two fatalities in 1992. Both cases have been reported extensively in public safety periodicals and the local press. A 35-year-old state police officer died in a raging water gorge while attempting to recover the body of a drowning victim. Reports indicate that the officer lost his footing and was pulled over a log jam into the waterfall and then into a whirlpool, where his body became jammed into some rocks by the powerful water force.

The discovery of an automobile partially submerged in a rain-swollen creek led to a rescue attempt by a lone fire/rescue diver. He conducted one dive without finding any persons and upon re-entering the water he was sucked under the vehicle and into a culvert which ran beneath the roadway. Though he was wearing a safety line attached to his waist, topside personnel were unable to pull him out. After the vehicle was removed, it took rescue divers about 30 minutes to release the victim. Ironically the vehicle accident had been reported earlier by the diver to another jurisdiction which had established that there were no persons in the wreck.

**Preliminary Information On 1993 Fatalities**

The collection of occupational fatalities for 1993 will continue into 1994. As of December 1, there have been a total of eight occupational diving fatalities for 1993.

Initial reports on an accident in the Gulf of Mexico led us to believe that one and possibly two divers died when the slings on a derrick barge lift failed and dropped a salvaged crew boat back into the water with two men trapped inside. New information has shown that neither of the victims was in a "diving" mode at the time and therefore can not be considered as occupational diving fatalities. This information is

included in this report to assure the reader that we have not simply missed a case.
One death has been classified as Category C-I. This was the death of a 33-year-old male salvage diver who was lost at sea 270 miles northeast of Oahu, Hawaii, while assisting a leaky barge. This death occurred in May, and the victim's body has not been recovered.

In Category C-IV we have noted four fatalities in 1993, one in Rhode Island in January and three in Maine. The latter three occurred within the period August to November.

The Rhode Island death was that of a 28-year-old male who was harvesting mollusks known as quahogs and may have become entangled in the lines from his surface-supplied air system. This death was further complicated by poor maintenance and oddly rigged equipment. The equipment analysis (conducted by NUADC) found at least five deficiencies, any one of which could have contributed to the event.

The three deaths in Maine this year, plus the two fatalities in 1992 have sparked a demand for state regulation of the sea urchin diving industry, which has nearly tripled in size in the last few years due to the great demand of the Japanese market, which considers the roe from this marine mollusk a delicacy.

All three of these deaths occurred while the victims were using scuba gear. One, a 52-year-old male, was very experienced, but the other two (and the 19-year-old in December of 1992) were newly trained sport divers. The latter three were fatally lured by the anticipation of an estimated $500 per day payoffs for their harvest.

In Category C-VII, we have recorded two deaths in 1993. The first occurred offshore of New Jersey in March and involved a commercial diver with more than 25 years' experience. This 57-year-old man was working at 150 feet searching for the bodies of five people lost after the sinking of a commercial tugboat in early March. After successfully recovering three of the victims, he had some malfunction of his helmet and despite heroic efforts by the crew, he died at the scene.

In Texas a 23-year-old man died underwater at a golf course pond in an incident similar to the two fatalities in Category C-VII in 1992. The victim was retrieving golf balls in 10 feet of water, when he failed to surface. He was reported to be extremely overweighted in addition to the golf balls he had been gathering.

One occupational diving fatality in 1993 has been placed in Category C-H. This 42-year-old police officer, a member of the underwater recovery team, apparently drowned while engaged in a dive at a golf course pond for the purpose of clearing an irrigation system drain pipe. He was on the surface alone with his mask off while his partner was submerged. A call from shore asking if he was all right elicited a "No" answer. He then floundered and went under despite his availability of buoyancy from either his compensator or the dry suit he was wearing. He was recovered quickly but died approximately two hours later. This case has been placed in C-H because the man was a "public safety diver" performing a public service while in an on-duty status.

The collection and reporting of occupational diver fatalities has always been supported through grant fundings from the National Oceanic and Atmospheric Administration (NOAA) and the Occupational Safety and Health Administration (OSHA). In recent years, the trend to cut government spending has led to minimal support of this project. Additional supporting funds and resources are also very limited. In all likelihood, this report represents the last effort to report on occupational diving fatalities. Hopefully, those agencies and individuals interested in the continuation of this project will come forward with financial support to maintain this important reporting process.

## Occupational Fatality Category Definitions

**Commercial I (C-I)**
Offshore construction and salvage diving, plus oil and gas-related
**Commercial II (C-II)**
Harbor and inland diving, such as construction, shallow pipe inspection, salvage and repair.
**Commercial III (C-III)**
Ship-related diving, such as construction, repair and hull cleaning.
**Commercial IV (C-IV)**
All types of commercial fisheries: abalone, sea urchin, seaweed harvesting, black coral diving, etc.
**Commercial V (C-V)**
Scientific diving for paid consulting purposes.
**Commercial VI (C-VI)**
Diving while in training for professional diving.
**Commercial VII (C-VII)**
Other types of commercial diving not specifically set forth in the above categories, such as underwater photography, private research, commercial treasure diving, archeological diving.

The categories which are not strictly commercial but are occupational in nature are listed as follows:
**Academic (F)**
Scientific research by persons associated with an academic institution.
**Government, military (G)**
On-duty divers in the U.S. Navy, U.S. Army, U.S. Coast Guard, etc.
**Government, civil (H)**
Local, state and federal employees, such as police and fire department search and rescue units, etc.
**Instructor, commercial (I)**
Those actively engaged in teaching commercial and professional diving.
**Instructor, recreational (J)**
Certified instructors actively engaged in teaching sport and recreational diving.
**Scientific diving (K)**
Individuals who meet the OSHA definition of scientific diving or are clearly a part of a scientific diving community.

## Occupational Fatality Table

| Categories | 1970-74 | 1975-79 | 1980-84 | 1985-89 | 1990 | 1991 | 1992 | TOTAL |
|---|---|---|---|---|---|---|---|---|
| Commercial I | 6 | 12 | 5 | 1 | 1 | 1 | 1 | 27 |
| Commercial II | 17 | 23 | 20 | 21 | 3 | 2 | 4 | 90 |
| Commercial III | 0 | 3 | 4 | 0 | 0 | 0 | 2 | 9 |
| Commercial IV | 14 | 21 | 18 | 22 | 6 | 3 | 3 | 87 |
| Commercial V | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| Commercial VI | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Commercial VII | 5 | 3 | 5 | 8 | 0 | 1 | 2 | 24 |
| Occupational F | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 5 |
| Occupational G | 2 | 6 | 6 | 1 | 3 | 0 | 0 | 18 |
| Occupational H | 3 | 3 | 7 | 8 | 0 | 0 | 2 | 23 |
| Occupational I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Occupational J | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 4 |
| Occupational K | 1 | 2 | 3 | 2 | 0 | 0 | 0 | 8 |
| **TOTALS** | **55** | **73** | **71** | **64** | **14** | **7** | **14** | **298** |

# Appendix H ICD-9-CM Codes for Dive-Related Incidents

36.10 Coronary artery bypass graft
36.11 CABG - one vessel
36.12 CABG - two vessel
36.13 CABG - three vessel
36.14 CABG - four vessel
36.15 CABG - internal mammary artery
245.1 Chronic thyroiditis
250.0 Diabetes mellitus
250.4 Diabetes mellitus w/ glomerulosclerosis
278.0 Obesity, exogenous
293.0 (Nitrogen narcosis)
293.0 Acute confusional state
303.0 Ethanol dependence syndrome
303.0 Unspecified
303.1 Continuous
303.2 Episodic
303.3 In remission
305 Non-dependent drug abuse
305.0 Alcohol abuse (acute)
305.1 Tobacco abuse
308.0 Panic state
336.1 Intraparenchymal hemorrhage of spinal cord
348.1 Anoxic brain damage
348.5 Cerebral edema
394.1 Mitral insufficiency
395.0 Aortic stenosis
398.90 Rheumatic heart disease
401.9 Hypertension
402.0 Hypertensive vascular disease (HVD)
404.0 HVD w/ renal involvement
410.9 Acute myocardial infarction
414.0 Coronary atherosclerosis
414.9 (Chronic myocardial ischemia)
414.9 Coronary artery disease
425.4 Hypertrophic cardiomyopathy
427.9 Cardiac dysrhythmia (unspecified)
427.41 Ventricular fibrillation
428.0 Congestive heart failure
428.1 Left heart failure (pulmonary edema)
429.2 Arteriosclerotic cardiovascular disease (ASCVD)

429.3 Ventricular hypertrophy (cardiomegaly)
436 Cerebrovascular accident (CVA)
490 Chronic obstructive pulmonary disease
492.0 Emphysematous blebs
492.8 Pulmonary emphysema
493.9 Asthma (unspecified)
496 COPD
508.9 Pulmonary edema due to external agent
512.0 Spontaneous pneumothorax
518.1 Pneumomediastinum
518.5 Acute respiratory distress syndrome (ARDS)
571.2 Cirrhosis of liver (alcoholic)
571.8 Fatty liver
780.0 Coma
780.3 Seizure disorder
786.09 Respiratory insufficiency
786.3 Pulmonary hemorrhage
798.1 Instantaneous death, cause not discovered
798.2 Death within 24 hours, cause not discovered
798.9 Body found after 24 hours, cause not discovered (i.e., mutilated, skeletonized, etc.)
799.9 Death, unspecified cause (body not found)
81.59 Bilateral hip prosthesis
853.0 Hemorrhage, brain-traumatic
854.0 Intracranial injury (head injury) closed or not specified
854.1 Intracranial injury, (head injury) open
860.0 Pneumothorax, tension, traumatic
958.0 Air embolism
958.7 Subcutaneous emphysema
980.0 Ethanol, toxic effect
986 Carbon monoxide poisoning (see E codes)
987.8 Oxygen toxicity
993.0 Barotrauma, otitic
993.1 Barotrauma, sinus
993.3 Decompression sickness
993 Barotrauma
994.1 Drowning and non-fatal submersion
E830 Watercraft accident (overturn)
E838.5 Struck by boat
E902.2 Rapid ascent
E906.3 Shark bites
E910.1 Recreational activity with diving equipment
E910.3 Diving for purposes other than recreation with diving equipment (i.e., marine salvage, rescue, construction, etc.)

E913.2 Insufficient air
E918 Caught, entangled, entrapment (specify)
E918.1* Shipwreck
E918.2* Cave, cavern, marine or freshwater
E918.3* Ice
E918.4* Kelp (or other underwater vegetation)
E918.5* Rope, line, cable, diving equipment
E918.9* Other entrapment

**Chemical Substances**

E868.9 Carbon monoxide accidental effect
E952.1 Carbon monoxide suicide attempt
E934.4 Benzodiazepine
E935.2 Codeine
E935.8 Propoxyphene
E937.0 Butalbital
E939.0 Fluoxetine (Prozac)
E939.0 Nortriptyline
E980.3 Cannabinoids
E980.3 Methamphetamine

* DAN adaptation of code

# Appendix I Diving Definitions

**Buoyancy Control** — The ability to maintain neutral buoyancy. Common causes are a current pushing a diver either up or down, being either over- or underweighted, overinflation of the bouyancy compensator, or lack of the actual skill.
**Current** — Refers to a strong or moderate current being present during the day of interest.

**Day of Interest** — Usually considered to be the day of the accident.

**Decompression Diving** — Diving exposure that requires staged in-water stops before continuing to the surface.

**Exertion** — The diver may exercise more than normal on a dive on the day of interest. The main causes of exertion during a dive are current or extra equipment (for photography or specialty diving).

**Fatigue** — At the time the diver first entered the water on the day of interest, the diver may have complained of being tired, experiencing a lack of sleep, or a generalized fatigue.

**≥ 80fsw** — At least one dive in the diver's profile on the day of interest is at 80 feet of sea water or deeper.

**< 2 year Experience** — The diver had been diving for less than 24 months on the day of interest.
**Multiday** — More than one day of diving was done in this particular dive series. Multi day and single day are mutually exclusive.

**Multilevel Dive** — The diver descends to one depth, staying at that depth for a while then either ascending or descending to a new depth for a while. Many different levels can be visited in one dive before finally ascending (for example, a diver descends to 60 feet and stays for 10 minutes then descends to 80 feet and stays for five minutes, ascends to 50 feet for 10 minutes and then to 20 feet for five minutes before surfacing).

**No-Decompression** — A dive which is within the recreational diving limits, not requiring a staged stop to allow the amount of nitrogen in body tissues to decrease before continuing to the surface. This can be with either tables or computers.

**Rapid Ascent** — The currently recognized recommended ascent rate is no faster than 60 feet per minute. A rapid ascent occurs when a diver ascends faster than recommended. Rapid ascents are often uncontrolled and can be caused by overinflation, being underweighted or panic.

**Repeat Dive** — More than one dive was done on the day of interest. Single dive and repeat dive are mutually exclusive.

**Single Day** — Only one day of diving was done in this particular dive series. Single day does not denote the number of dives, rather a single day of diving (for example, four dives could be done in a single day, or one dive could be done in a single day).

**Single Dive** — Only one dive was done on the day of interest.

**Square Dive** — The diver descends to maximum depth staying at that depth until ascending to the surface (for example, a diver descends to 60 feet and stays at 60 feet for 30 minutes before ascending). Square and multilevel dives are mutually exclusive.

**Within Tables** — A dive which is within the allowable limits of the dive planning table or device used by the diver.