Report on Decompression Illness and Diving Fatalities

The Annual Review of Recreational Scuba Diving Injuries and Deaths Based on 1995 Data

Divers Alert Network

DAN

1997 Edition

REPORT

on

Decompression Illness and Diving Fatalities

1997 Edition

The annual review of recreational scuba diving injuries and deaths based on 1995 data

by

DAN
Divers Alert Network

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This 1997 edition includes accidents and fatalities that occurred from Jan. 1-Dec. 31, 1995.

Divers Alert Network's *Report on Decompression Illness and Diving Fatalities* represents self-reported, retrospective data from hyperbaric chambers that share accident and fatality data with DAN.
This edition, published in 1997, includes reports on decompression illness and diving-related fatalities that occurred in the calendar year 1995 — Jan. 1 - Dec. 31, 1995. It is referred to throughout as the *Report*, or the 1997 edition of the *Report*.

In 1995, 1,132 cases of decompression illness (DCI) were reported to DAN through hyperbaric treatment facilities. DAN received *Diving Accident Reporting Forms* on 809 cases. Of these 809 reports, 590 DCI cases met the criteria for inclusion in the DAN 1995 database. Trends in the accident database are reported on a nine-year period, from 1987 through 1995. The *Report* also reviews 104 recreational scuba fatalities.

The DAN reporting forms on accidents, fatalities and dive incidents which have previously appeared as appendices in past editions of this *Report* have been removed. If you would like a copy of any of these reporting forms, please call the DAN Medical Department at (919) 684-2948.

The DAN *Dive Incident Reporting Form*, which is used to document events that lead to "near-misses" but do not result in a decompression illness or dive fatality, can be found on the DAN Worldwide Web page at http://www.dan.ycg.org. Incident reporting is very important to DAN's data collection; although no harm has come to the diver, this collection of incident data could help provide answers to dive safety questions.

As with most DAN programs, the majority of the funding for this report is derived from annual DAN membership dues.

DAN also wishes to recognize the many DAN Sponsor dive clubs, stores, instructors, corporations and friends of DAN who support DAN and dive safety.

Cover photos by DAN members Chris Crumley (top photo) and William Pierro. Cover design by Phillip Daquila.

Acknowledgments

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DAN Volunteer First-Call Senior Staff Physicians

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Christopher DeBacker M.D.	*Guy de L. Dear M.B., FRCA*
David N. DuBois M.D.	*G. Yancey Mebane M.D.*
Karl Peter Fritz M.D.	*Richard Moon M.D.*
Tong Joo Gan M.D.	*Claude A. Piantadosi M.D.*
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DAN's Dive Incident Reporting Form can be found on the DAN Worldwide Web page at http://www.dan.ycg.org

DAN's database of dive accidents and fatalities gets worldwide support through the management and expertise of Regional Coordinators.

DAN Regional Coordinators

Southeast Region and Headquarters — *Alabama, Florida, Georgia, North Carolina, South Carolina, Tennessee and Caribbean Basin*
Peter Bennett Ph.D., D.Sc., and **Richard Moon M.D.**
F.G. Hall Hyperbaric Center, Box 3823, Duke University Medical Center, Durham, NC 27710.

Southwest Region — *Arizona, California, Nevada and Utah*
Hugh Greer M.D.
Santa Barbara Medical Foundation Clinic, Department of Preventive/Occupational Medicine, Box 1200, Santa Barbara, CA 93102

Northeast Region — *Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia and West Virginia*
Roy Myers M.D. and **Cynthia Cotto-Cumba M.D.**
Department of Hyperbaric Medicine, Maryland Institute for Emergency Medical Services Systems, Department of Hyperbaric Medicine, University of Maryland, 22 S. Greene Street, Baltimore, MD 21201

Gulf Region — *Arkansas, Colorado, Kansas, Louisiana, Mississippi, Missouri, New Mexico, Oklahoma and Texas*
Keith Van Meter M.D. and Randy Springer, CHT.
Jo Ellen Smith Medical Center, 4400 General Meyer Avenue, New Orleans, LA 70131

Midwest Region — *Illinois, Indiana, Iowa, Kentucky, Michigan, Minnesota, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin and Wyoming*
Robert Goldmann M.D. and **Mr. Stephen Fabus**
Department of Hyperbaric Medicine, St. Luke's Medical Center, 2900 W. Oklahoma Avenue, Milwaukee, WI 53215

Northwest Region — *Alaska, Idaho, Montana, Oregon and Washington*
Neil Hampson M.D. and **Richard Dunford M.S.**
Hyperbaric Department, Virginia Mason Research Center, 952 Seneca Street, Seattle, WA 98111

Pacific Region — *Guam, Hawaii, and U.S. Territories*
Robert Overlock M.D. and **Mr. Frank Farm**
Hyperbaric Treatment Center, University of Hawaii, John A. Burns School of Medicine, 42 Ahui Street, Honolulu, HI 96813

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DAN — *Your* Dive Safety Association

Today DAN members comprise the largest association of recreational divers in the world

For scuba divers worldwide, DAN means safety, health and peace of mind. DAN is a 501(c)(3) nonprofit dive safety association affiliated with Duke University Medical Center in Durham, N.C.

DAN was founded in 1980 to provide an emergency hotline to serve injured divers and the medical personnel who care for them. Originally funded by government grants, today Divers Alert Network relies on membership, dive industry sponsors, product sales and fund-raising to provide the high level of service the dive community has become accustomed to receiving.

DAN members comprise the largest association of recreational divers in the world. DAN is best known for its 24-Hour Diving Emergency Hotline, the Dive Safety and Medical Information Line and its dive medical research programs. However, DAN America and its affiliates in Europe, Japan and Southeast Asia also serve the recreational scuba community with dive first aid training programs, dive emergency oxygen equipment, affordable dive accident insurance, and books and videos on scuba safety and health.

DAN America's Services to the Recreational Diving Community

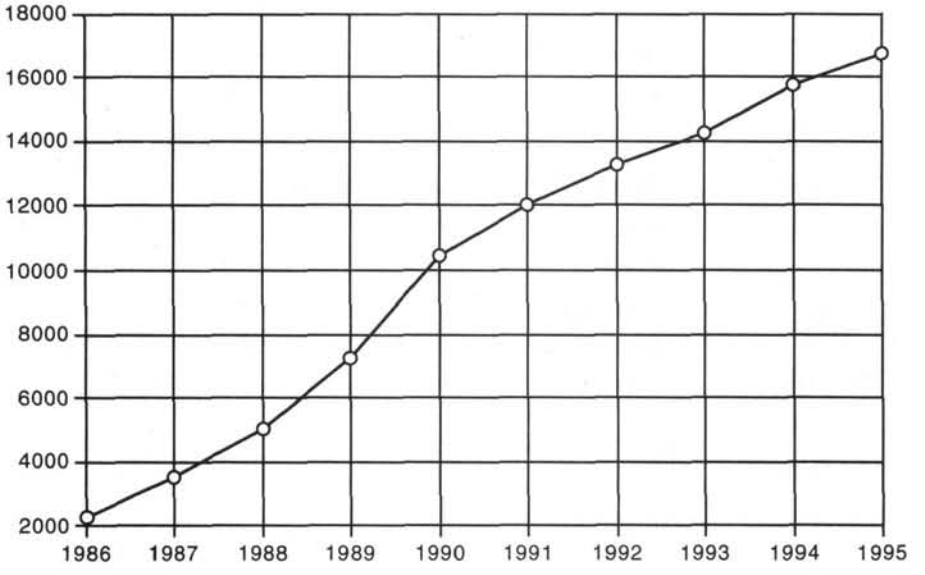
The DAN Mission

✦ ***DAN's historical and primary function is to provide emergency medical advice and assistance for underwater diving accidents, to work to prevent accidents and to promote diving safety.***

✦ ***DAN promotes and supports underwater diving research and education, particularly as it relates to the improvement of diving safety, medical treatment and first aid.***

✦ ***DAN strives to provide the most accurate, up-to-date and unbiased information on issues of common concern to the diving public, primarily, but not exclusively, for diving safety.***

DAN Emergency and Information Services Combined Telephone Call Volume



■ DAN Diving Emergency Hotline — (919) 684-8111

The 24-Hour Diving Emergency Hotline at (919) 684-8111 is DAN's primary service. The Hotline offers emergency consultation and referral services to injured divers worldwide. In 1995, as in previous years, DAN answered more than 2,000 calls for emergency assistance from its members and divers. DAN members comprise the largest association of recreational divers in the world.

■ DAN Medical Information Line — (919) 684-2948

DAN's Medical Information Line at (919) 684-2948 is available weekdays from 9 a.m. to 5 p.m. Eastern Time (1400-2200 Greenwich Mean Time). When divers have questions about their health and how it might affect their diving, finding a dive physician in their area, questions on medicines and diving, or to find out about diving after surgery, the Medical Line is there to help them.

The DAN Medical Department received 14,642 information calls in 1995. The Medical Information Line is designed to allow callers to talk to a specially trained diving medical technician about non-emergency diving safety and health concerns. If callers need assistance in answering a question, DAN medics have the resources of DAN on-call physicians, the diving medicine researchers at Duke University Medical Center's F.G. Hall Hypo-Hyperbaric Center and other experts.

In some cases, DAN may refer callers to a diving specialist or physician in their region for further evaluation. Since DAN's beginnings more than 16 years ago, over 130,000 callers have been assisted through the use of these telephone services.

In 1995 DAN took more than 2,000 calls for emergency assistance from members and divers.

DAN Dive Health and Safety Research

Based at Duke University Medical Center's F.G. Hall Hypo-Hyperbaric Center, DAN's Research Division is dedicated to scientific medical study of diving health issues. DAN is the only association that investigates medical issues that affect recreational diving.

Some of DAN's dive safety and health research projects include the Flying After Diving studies, Project Dive Safety and the diving with diabetes study.

Flying After Diving Study

One of DAN's most ambitious programs is a study using volunteer test subjects for studies in flying after diving. The experiment, which simulates various dive profiles and a subsequent flight at typical commercial airline cabin altitudes (8,000 feet/2,432 meters), is being researched jointly by DAN and F.G. Hall Hypo-Hyperbaric Center. The goal is to develop guidelines for recreational divers for safe intervals between diving and flying aboard a commercial airliner.

Project Dive Safety

Another current study is Project Dive Safety, DAN's long-term collection of diving data. DAN researchers are currently using recording dive computers worldwide to collect information on dive profiles. Its goal is to create the largest database of its kind in an effort to provide more insight into the behavior, dive profiles and characteristics of recreational scuba divers in relation to DCI.

Other Projects

In 1996, DAN began seeking approval for a study to determine the risks of diving with diabetes. The project was approved by Duke University Medical Center's institutional review board late in 1996. DAN is launching this project early in 1997.

This research requires the use of expensive, specialized hypo-hyperbaric scientists and physicians, software development and technical staffing. The DAN projects are privately funded through DAN membership and dive industry support. Without DAN, many important questions about recreational diving safety would not only remain unchallenged, but unanswered.

Other major projects include a NASA-funded study at Duke's F.G. Hall Hypo-Hyperbaric Center to determine how exercise and microgravity affect decompression illness in astronauts during "space walks" or extravehicular activity (EVA). There is also a NOAA-funded project to develop decompression procedures for scientific divers, and a U.S. Navy-funded project to develop a dive computer and diving database.

DAN Support to the Dive Medical Community

With DAN's Recompression Chamber Assistance program, DAN provides training and financial support to recompression chambers throughout the Caribbean and other popular dive destinations, to ensure that they remain in operation and stay properly staffed. This program complements DAN's biannual dive medical courses for physicians, nurses and paramedics to educate the international medical community on the proper care and treatment of injured divers.

In 1996, DAN once again broke new ground in the field of dive accident treatment and insurance, by creating a Diving Preferred Provider Network (DPPN) of hyperbaric chambers to help manage the costs of recompression treatment and make it easier for hyperbaric facilities to receive payment for their services.

DAN Oxygen First Aid Training

For scuba instructors and dive enthusiasts, DAN offers the world's most popular oxygen first aid program, launched in 1991. Until DAN developed its oxygen training program and line of oxygen equipment, many injured divers did not benefit from the use of emergency oxygen. As of October 1996, more than 50,000 divers and 5,700 diving professionals have been trained under this program. DAN also distributes a line of specialized oxygen delivery systems for the treatment of injured divers.

For years DAN has strongly advocated the ready availability of emergency oxygen in diving accidents. In 1996, the U.S. Food and Drug Administration (FDA) reaffirmed its policy on the use of emergency oxygen without a prescription. In the state of Florida, certified divers can now purchase oxygen and emergency oxygen equipment. DAN was instrumental in influencing these decisions. Lowering this barrier to access of oxygen was another step by DAN to ensure that injured divers would have emergency oxygen available when needed.

DAN On-Line — http://www.dan.ycg.org

DAN's Web Site on the World Wide Web provides a wealth of information on scuba health and safety and the many benefits of DAN membership. You can get answers to frequently asked dive medical questions, find a DAN retail sponsor near you, sign up for DAN membership and more.

DAN Research On-Line — http://jshaldane.mc.duke.edu

DAN's Research Department has a Web Site to communicate information on DAN research — particularly Project Dive Safety and Flying After Diving. Software for collecting information about dive profiles and diving accidents can be downloaded at no cost.

Launched in 1991, DAN's oxygen program is the world's most popular oxygen first aid program.

DAN America Membership Services

In addition to membership, DAN members are eligible for dive accident insurance, with three different levels of coverage.

In addition to supporting diving's only 24-hour diving emergency hotline, DAN members receive a number of valuable benefits, including emergency travel assistance, a subscription to award-winning *Alert Diver* magazine, the DAN *Dive and Travel Medical Guide* and dive and travel discounts. DAN members are also eligible for affordable dive accident insurance coverage and the exclusive DAN Tag™, diving's only emergency ID system.

As of October 1996, approximately 160,000 members support DAN in the United States, the Caribbean and Canada. As DAN members, they receive the following dive and travel benefits:

DAN *TravelAssist*

One of the automatic benefits of membership with Divers Alert Network is DAN *TravelAssist*. This services provides up to $100,000 emergency medical evacuation assistance for *any* injury or illness — dive-related or not — incurred outside a 50-mile radius from home by a DAN member or a DAN family member.

Alert Diver Magazine

DAN members receive a subscription to award-winning *Alert Diver* magazine, the only publication dedicated to diving safety and health.

DAN *Dive and Travel Medical Guide*

New DAN members receive a copy of the DAN *Dive and Travel Medical Guide*, a valuable reference on treating common diving and travel injuries and illnesses.

DAN Dive Accident Insurance

DAN members are eligible for three different levels in insurance programs, and in 1996, DAN significantly improved the benefits of each level. The DAN Master Plan, in combination with DAN membership benefits, offers more than $250,000 of protection for diver and travelers. DAN currently offers three levels— the Master, Plus and Standard Plans, in addition to DAN membership.

DAN pioneered dive accident insurance in 1987, and in 1992 launched medical evacuation assistance benefits for its members. These moves helped fill a medical and financial need that was not being met by any other organization at the time, and provided DAN members with additional benefits. In the past, divers had often been saddled with large medical bills, because most health insurance would not cover any or all of the charges associated with a diving injury. This problem still exists for some divers, though DAN strives to help bridge this gap.

DAN Dive Accident Insurance

Master Plan	Plus Plan	Standard Plan
Total Protection, including DAN TravelAssist: $260,000	Total Protection, including DAN TravelAssist: $170,000	Total Protection, including DAN TravelAssist: $145,000
Depth Limits: None	Depth Limits: 130 feet	Depth Limits: 130 feet
Price: $35/year ‡	Price: $30/year ‡	Price: $25/year ‡
Coverage: $125,000 (lifetime) for decompression illness and in-water injuries*	Coverage: $50,000 (lifetime) for decompression illness*	Coverage: $45,000 (lifetime) for decompression illness*
$15,000 for accidental death and dismemberment	$10,000 for accidental death and dismemberment	
$15,000 for permanent total disability	$10,000 for permanent total disability	
$1,500 accommodations		
$1,000 airline ticket		
$2,500 lost dive equipment		

‡ *Plus the price of DAN membership*

* *For more detailed information on DAN insurance, please call DAN Member Services at 1-800-446-2671, 9 a.m.-5 p.m. Eastern Time, Monday-Friday.*

DAN Dive Health and Safety Products

DAN's product line includes a variety of books and videos on the subject of dive safety and health, as well as DAN's line of emergency oxygen equipment. The DAN Product Catalog listing these and other DAN products is available in every issue of *Alert Diver*. DAN members receive a special member price on all DAN products. Selected products from the DAN product catalog will be available for sale on DAN's Web Site in 1997.

DAN Tag

In 1995, DAN introduced the first medical ID tag created exclusively for divers — the DAN Tag™. Each clip-on ID tag is personalized with vital membership, medical and contact information in the unlikely event of a diving emergency. Only DAN members can purchase the DAN Tag. A portion of DAN Tag sales go directly to support DAN's Diving Emergency Hotline and DAN Dive Research.

In 1995, DAN introduced the DAN Tag, the first medical ID tag created for divers.

Because DAN's records are kept in one secure location, DAN can verify membership benefits and insurance coverage right away, and make arrangements for timely evacuation and recompression treatment.

■ DAN 24-Hour Diving Emergency Hotline / Immediate Insurance Verification

Dive and travel medical emergencies can happen at any time, any day of the week. Callers to DAN's 24-hour Diving Emergency Hotline can reach a person who is specially trained and experienced to handle dive and travel medical emergencies ***at any time***, day or night.

With DAN's exclusive record-keeping system, DAN member emergency medical evacuation assistance and dive accident insurance policy records are kept in one central confidential location at DAN. As a DAN member, if you (or your friend, spouse or physician) call DAN's 24-Hour Diving Emergency Hotline, DAN can verify membership benefits and insurance coverage right away, and make arrangements for timely evacuation and recompression treatment.

■ DAN Membership Discounts

DAN members are eligible for special discounts, including rental car and airline tickets. Check *Alert Diver* magazine for the most recent offers or call DAN's Member Services Department at (800) 446-2671.

■ DAN is *Your* Dive Safety Association.

Join today. **Call (800) 446-2671, or visit DAN on the World Wide Web at www.dan.ycg.org**

Introduction to Scuba Accidents

Focus on Decompression Illness and Fatalities

This edition of DAN's *Report on Decompression Illness and Diving Fatalities* is based on data gathered in the year 1995 on treated cases of decompression illness and on confirmed fatalities and published in 1997. It is referred to throughout as the *Report*, or the 1997 edition of the *Report*, and is the ninth annual report published by DAN.

The *Report* is divided into two major sections: the first focuses on diving injuries resulting from decompression illness (DCI); the second division, beginning with section 6.0, discusses fatalities involving recreational scuba divers. DAN's accident database now contains data on 3,954 cases of DCI treated over the past nine years and 3,022 cases since 1990.

Decompression Illness (DCI)

Decompression illness is a general term used to describe a broad spectrum of signs and symptoms of inert gas problems, or dysbaric injuries, related to scuba diving. Arterial gas embolism (AGE) and decompression sickness (DCS) are the conventional terms used to describe two different and specific types of DCI injuries.

Arterial gas embolism, or AGE, is characterized by gas bubbles in the arterial system generally caused by air passing through the walls of the alveoli into the bloodstream. AGE can result after breathing compressed gas followed by voluntary breathholding; or it can result from a pathological condition, which traps air in the lungs while ascending to the surface. Symptoms of AGE are usually immediate in onset and commonly involve changes in the level of consciousness, paralysis or other cerebral symptoms.

Decompression sickness, or DCS, is a syndrome caused by bubbles of inert gas forming in the tissues and bloodstream which evolves from too rapid an ascent during scuba diving. DCS usually results from a deep dive or a prolonged exposure to breathing compressed gas at depths greater than 30 feet. Symptoms generally occur more gradually than with AGE and frequently consist of pain, numbness, tingling and other central nervous system symptoms.

Why DAN Collects This Data

DAN collects accident data to obtain details on how decompression sickness and arterial gas embolism occur in recreational scuba divers.

AGE symptoms are usually immediate in onset and commonly involve paralysis, changes in the level of consciousness, or other cerebral symptoms.

DCS usually results from a deep dive or a prolonged exposure to breathing compressed gas at depths greater than 30 feet.

DAN collects data on dive accidents in an effort to help inform and educate the diving community — from recreational divers, to dive researchers to medical doctors.

This information is also valuable in determining changes or trends in the types of diving injuries and symptomatology that occurs, as well as how emergency treatment (recompression therapy) affects the outcome.

This information can then be used to help inform and educate the diving community — from recreational scuba divers, to dive researchers, to medical doctors.

Data from previous years have been combined into three-year increments. This is done to show the consistency of trends or changes in trends by allowing the reader to compare yearly results.

How DAN Does It

Each year DAN contacts hyperbaric recompression facilities that treat injured divers worldwide to determine the number of treated cases of DCI. The total number of DCI cases reported for the years 1993-1995 are shown in Table 1.1 (page 15). Appendix H shows totals for 1986-1992.

Decompression Illness

Table 1.1 shows a breakdown of decompression illness cases by conventional diagnoses, which are:

- **Type I decompression sickness**, or DCS-I — which refers to skin bends, fatigue or pain only;
- **Type II decompression sickness**, or DCS-II — which includes neurological and cardiorespiratory bends;
- **Arterial gas embolism** *(AGE)* represents arterialized gas bubbles primarily associated with immediate cerebral symptoms.

These diagnoses are the ones assigned by the treating physician at the hyperbaric facility. Table 1.1 (page 15) represents the total cases treated in 1995 separated according to the DAN region in which the treatment was received. The Caribbean Basin is included within the totals for the Southeastern United States.

Table 1.2 (pages 15-17) represents the total number of cases by diagnosis reported to DAN in 1995, separated by regions and states within that region. The Caribbean basin is represented separately in this table.

The numbers for 1995 represent the total number of treated cases reported from 37 states, 16 countries and three U.S. territories — Guam, U.S. Virgin Islands and Puerto Rico. Although there may be some non-U.S. residents treated at U.S. facilities, the number of treated cases for any given year refers primarily to U.S. and Canadian residents, who are treated in U.S., Canadian and overseas chambers.

TABLE 1.1 *Total Reported Cases by Year and Region* **

1995	Other*	SW	NW	MW	GU	PA	NE	SE+	TOTALS
DCS-I	1	70	21	9	30	0	34	97	262
DCS-II	7	95	40	20	89	15	56	316	638
AGE	0	20	1	2	11	4	2	37	77
No case breakdown	0	0	0	0	0	72	15	68	155
TOTALS	**8**	**185**	**62**	**31**	**130**	**91**	**107**	**518**	**1,132**

1994	Other*	SW	NW	MW	GU	PA	NE	SE+	TOTALS
DCS-I	3	39	13	13	26	1	39	93	227
DCS-II	14	59	50	24	68	8	85	336	643
AGE	2	18	5	2	16	15	3	30	91
No case breakdown	14	40	0	11	1	77	6	53	202
TOTALS	**33**	**156**	**68**	**50**	**111**	**101**	**133**	**512**	**1,163**

1993	Other*	SW	NW	MW	GU	PA	NE	SE+	TOTALS
DCS-I	3	33	12	9	22	10	37	92	218
DCS-II	18	90	42	33	75	52	40	292	642
AGE	1	13	10	2	1	13	4	44	88
No case breakdown	3	0	0	0	0	0	0	7	10
TOTALS	**25**	**136**	**64**	**44**	**98**	**75**	**81**	**435**	**958**

* *Includes all foreign countries and U.S. military personnel (these cases involved active-duty military personnel who were diving recreationally and treated in military chambers).*

\+ *SE includes Caribbean basin.*

** *See Table 1.2 (below) for breakdown of reporting regions.*

TABLE 1.2 *Total Cases Treated & Reported in 1995 by Region*

Southwest Region	DCS-I	DCS-II	AGE	TOTALS
Arizona	5	4	0	9
California	64	85	20	169
Nevada	1	1	0	2
Utah	0	5	0	5
TOTALS	**70**	**95**	**20**	**185**

Northwest Region	DCS-I	DCS-II	AGE	TOTALS
Idaho	0	2	0	2
Montana	1	1	0	2
Oregon	4	4	1	9
Washington	16	34	0	50
TOTALS	**21**	**40**	**1**	**62**

* *Specific diagnoses were not provided in some of these cases.*

TABLE 1.2 *(continued) Total Cases Treated & Reported in 1995 by Region*

The numbers for 1995 represent the total number of treated cases reported from 37 states, 16 countries and three U.S. territories — Guam, U.S.Virgin Islands and Puerto Rico.

Midwest Region	DCS-I	DCS-II	AGE	TOTALS
Illinois	2	5	0	7
Indiana	0	4	0	4
Iowa	1	0	0	1
Michigan	2	6	1	9
Minnesota	0	3	0	3
Nebraska	1	0	0	1
Ohio	1	1	1	3
Wisconsin	2	1	0	3
TOTALS	**9**	**20**	**2**	**31**

Gulf Region	DCS-I	DCS-II	AGE	TOTALS
Colorado	1	17	0	18
Kansas	3	0	0	3
Louisiana	7	13	1	21
Missouri	1	5	0	6
Oklahoma	2	1	0	3
Texas	16	53	10	79
TOTALS	**30**	**89**	**11**	**130**

Pacific Region	DCS-I	DCS-II	AGE	TOTALS
Hawaii	0	0	0	72*
Guam	0	15	4	19
TOTALS	**0**	**15**	**4**	**91**

Northeast Region	DCS-I	DCS-II	AGE	TOTALS
Connecticut	0	6	0	6
Maine	0	2	0	2
Maryland	5	5	0	10
Massachusetts	1	0	0	14*
New Jersey	1	13	0	14
New York	19	22	1	44
Pennsylvania	7	3	1	11
Virginia	1	5	0	6
TOTALS	**34**	**56**	**2**	**107**

* *Specific diagnoses were not provided in some of these cases.*

TABLE 1.2 *(continued)* *Total Cases Treated & Reported in 1995 by Region*

Southeast Region	DCS-I	DCS-II	AGE	TOTALS
Alabama	5	6	0	12*
Florida	38	132	19	255*
Georgia	8	2	0	10
North Carolina	15	21	1	37
South Carolina	4	3	0	8
Tennessee	1	1	0	2
TOTALS	**71**	**165**	**20**	**324**

Caribbean Basin	DCS-I	DCS-II	AGE	TOTALS
Bahamas	0	7	1	8
Barbados	2	1	1	4
Belize	0	19	2	21
Bermuda	0	7	1	8
Bonaire	0	4	0	4
Cabo San Lucas	2	4	1	7
Cayman	1	21	2	24
Cozumel	9	40	6	55
Honduras	2	9	0	11
Jamaica	0	2	0	2
Panama (Canal Zone)	0	2	0	2
Puerto Rico	1	11	1	13
Saba	5	5	1	11
St. Thomas	2	3	1	6
Turks & Caicos	2	16	0	18
TOTALS	**26**	**151**	**17**	**194**

Other	DCS-I	DCS-II	AGE	TOTALS
Australia	0	2	0	2
Fiji	0	4	0	4
Palau	1	1	0	2
TOTALS	**1**	**7**	**0**	**8**

* *Specific diagnoses were not provided in some of these cases.*

Although there may be some non-U.S. citizens treated at U.S. facilities, the number of treated cases for any given year refers primarily to U.S. and Canadian citizens, who are treated in U.S., Canadian and overseas chambers.

Collection of DAN Database Cases

Divers Alert Network utilizes a network of 264 hyperbaric chambers in the United States and around the world to report decompression illness (DCI) injuries. The DAN network is divided into seven regions, each overseen by a Regional Coordinator (see the entry on page 4 for the listing of specific regions and their respective Regional Coordinators).

Regional Coordinators remain in contact with the hyperbaric treatment centers in their areas and help collect Diving Accident Reporting Forms (DARFs).

These Regional Coordinators remain in contact with the hyperbaric treatment centers in their areas and help collect *Diving Accident Reporting Forms* (DARFs), which provide injured divers a means by which to document their injury. These cases reports are then sent to DAN. Regional Coordinators also assist in directing injured divers to the nearest qualified area medical centers for evaluation and treatment.

These DARFs are then sent to DAN for further verification before their final inclusion in DAN's accident database.

Most chambers send Diving Accident Reporting Forms directly to DAN. Some chambers rely on the patients to fill out the form and send it to DAN, while a few do not offer the forms for reporting.

Each year, DAN surveys hyperbaric treatment centers to solicit their participation in the reporting program. In 1995, of the 1,132 cases of treated DCI reported to DAN by phone, DAN actually received only 809 DARFs reporting these incidents. With DAN DARFs, the names and identifying personal information are confidential and available to anyone outside the DAN medical and research departments.

Accident data is not used to imply individual fault or blame but to determine the cause of scuba accidents and any common trends to certain outcomes. The number of individuals with DCI who did not seek medical attention, or who were not referred for treatment, is unknown.

DAN DARFs on 1995 data need to be received at DAN Headquarters no later than June 1, 1996, to be included in this *Report*. As of June 1, 1996, DAN had received 809 DARFs. Divers who were treated at more than one hyperbaric facility were counted only once unless they were injured in a second, separate episode of DCI in the same calendar year.

When an accident case is received at DAN it is logged into a tracking database. The DAN medical information specialists then follow up on all cases that meet the inclusion criteria (see page 19). Cases are not followed up if the person involved could not be located or failed to remember accident details. Patients with residual symptoms at the time of follow-up are contacted by DAN three months after the accident or until they no longer have residual symptoms.

Inclusion Criteria

Of the 809 DARFs received, 590 met the criteria for inclusion in the DAN accident database. This represents 73 percent of the cases where DARFs were received at DAN. To be included in the DAN database, a case must meet the following criteria.

Inclusion Criteria

- The diver must be a recreational scuba diver using scuba and breathing compressed air only.
- Only scuba instructors or divemasters providing dive instruction are included under "work-related" injuries.
- The diver must be a U.S. or Canadian resident.
- Final diagnosis by the treating hyperbaric physician must be decompression illness.
- Cases must be received by June 1 of the following year for each collection year (e.g., June 1, 1996, for the 1995 reporting year).
- Case must have been followed up by DAN.

A total of 219 cases were excluded from the DAN accident database for the reasons cited below.

Exclusion Criteria

- The injured diver was a commercial, occupational or scientific diver (n = 46);
- The injured diver was not a resident of the United States or Canada (n = 60);
- DCI was not diagnosed; i.e., the injury was something else, such as ear barotrauma, pulled muscle, or marine life envenomation (n = 57);
- Diver was using surface-supplied air or was breath-hold diving (n = 14);
- Cases in which no follow-up was possible by DAN medical staff because of a legal concern or the person was unable to be located (n=26).

Divers using gas mixtures other than air to make recreational or recreational/technical dives who suffered a decompression illness accident are discussed for the first time in the history of the *Report* in a separate appendix (Appendix E). They do not appear in the 590 cases noted above.

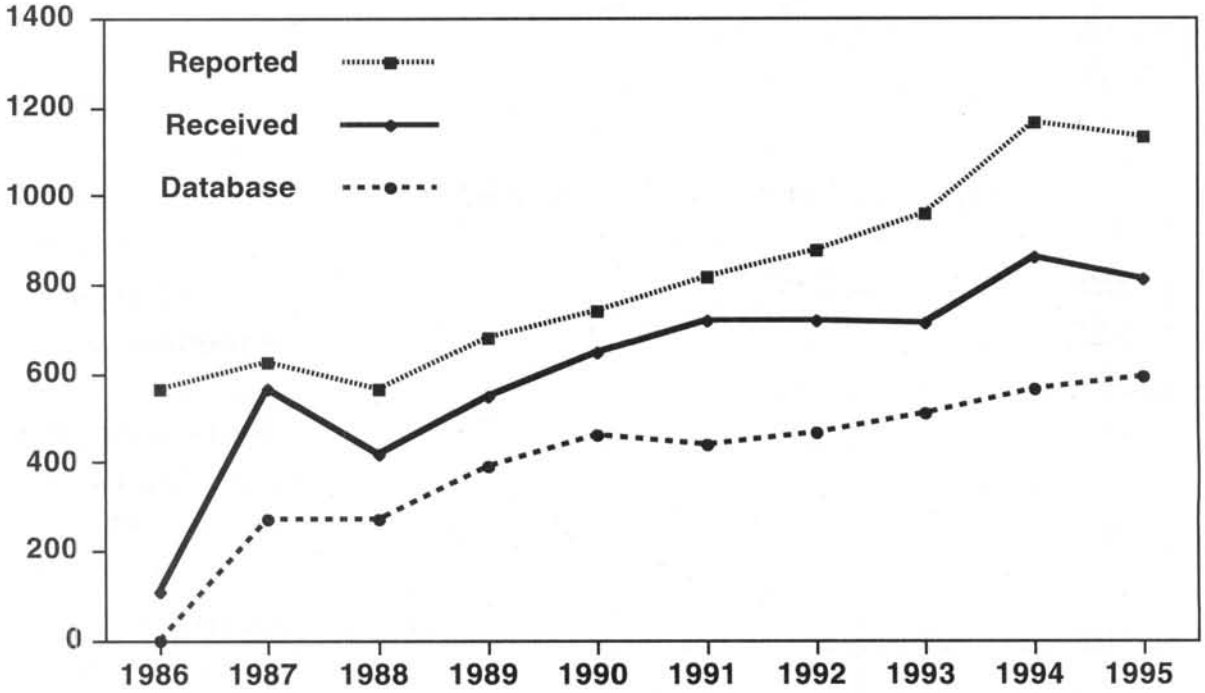
Graph 1.1 on the following page shows the dive accident reporting and collection trends since 1986.

The top solid line indicates the total number of cases reported to DAN by phone yearly (1,132 in 1995); the middle dotted line represents the total number of DARFs sent to DAN for review (809); and the bottom dashed line represents the total number of cases which met the criteria for inclusion in the 1995 DAN accident database (590).

In 1995, 590 cases met the criteria to be included in the DAN accident database.

Divers using mixed gases to make recreational/ technical dives are discussed for the first time in the history of the* Report *in Appendix E.

Graph 1.1 ***Total Number of Cases Reported Received and Completed by DAN***



The 'n' is a statistical notation that represents the population size or the number of injured divers depicted in that table or graph.

Database Cases

In a number of the 590 accident cases in 1995, respondents did not fully complete the reporting forms. In the event a question is not answered, tables in the report may show a *frequency missing* = 'x,' where 'x' is the number of cases in the database that did not respond to that question.

The 'n' is a statistical notation that represents the population size or the number of injured divers depicted in that table or graph.

Percentages were rounded to the nearest tenth or hundredth. Many tables have categories which include very few responses, which has resulted in a small number (i.e., the number of respondents replying yes) divided by a large number (i.e., the total number of respondents). This leads to occasional rounding errors and percentages totaling slightly less than or more than 100 percent.

The location of the dive accident for the 590 cases analyzed in this report are contained in Tables 1.3 and 1.4 where the data has been sorted by cases that meet database inclusion criteria.

Table 1.3 (below) shows the number of cases broken down by country (n = 590); and Table 1.4 on the following page represents the number of accidents treated in the U.S. states and territories (n = 381).

Tables 1.3 and 1.4 show where the accident occurred but do not necessarily indicate treatment locations.

Table 1.3 shows the number of cases broken down by country; and Table 1.4 represents the number of accidents treated in the U.S. states and territories.

Table 1.3 *Accidents by Country & U.S. Territories*

Country	Frequency	Percentage
Bermuda	1	0.2
Grenada	1	0.2
Israel	1	0.2
Philippine Islands	1	0.2
Turkey	1	0.2
Tortola	1	0.2
Jamaica	2	0.3
Truk	2	0.3
Turks & Caicos	2	0.3
Australia	3	0.5
British Virgin Islands	3	0.5
Fiji	3	0.5
Palau	3	0.5
Barbados	4	0.7
Bonaire	4	0.7
Canada	4	0.7
Honduras	6	1.0
Antilles	8	1.4
US Territories	**10**	**1.7**
Bahamas	19	3.2
Caymans	22	3.7
Belize	31	5.3
Mexico	87	14.7
USA	**371**	**62.9**
TOTAL	**590**	**100.0**

Tables 1.3 and 1.4 show where the accidents occurred but do not necessarily indicate treatment locations.

Table 1.4 *Accidents by U.S. States & Territories*

State	Frequency	Percent
Arizona	1	0.3
Georgia	1	0.3
Guam*	1	0.3
Iowa	1	0.3
Maine	1	0.3
Massachusetts	1	0.3
Tennessee	1	0.3
Virginia	1	0.3
West Virginia	1	0.3
Wisconsin	1	0.3
Colorado	2	0.5
Connecticut	2	0.5
Maryland	2	0.5
Montana	2	0.5
Ohio	2	0.5
Oregon	2	0.5
Puerto Rico*	2	0.5
New Mexico	3	0.8
Nevada	4	1.1
Alabama	5	1.3
Pennsylvania	5	1.3
Louisiana	6	1.6
Michigan	6	1.6
Rhode Island	6	1.6
South Carolina	6	1.6
US Virgin Islands*	7	1.8
New Jersey	9	2.4
New York	11	2.8
Texas	15	3.9
North Carolina	20	5.3
Hawaii	36	9.5
California	43	11.3
Washington	52	13.6
Florida	123	32.3
TOTALS	**381**	**100.0**

* *US Territories*

Summary

DAN telephone services refers hundreds of callers with suspected DCI to hyperbaric facilities. Not all callers will follow the advice of the medical specialist and receive medical treatment. The DAN Medical Department made follow-up contacts with all of the hyperbaric chambers in its referral network to collate the total number of DCI accidents that were treated.

In 1995, 1,132 cases of DCI were treated in the chambers that work with DAN. Of these cases, 809 Diving Accident Reporting Forms (DARFs) were sent to DAN. All cases are followed up, when possible, and entered into the DAN accident database. In 1995, 590 cases were included in the accident database.

This report on 1995 data represents 42.8 percent of the total number of divers treated by reporting hyperbaric facilities. Since the first annual *Report* in 1987, 42 to 62 percent of all divers treated have been included in DAN's accident database. The number of referrals and follow-up calls by DAN's medical staff has led to more symptomatic individuals being referred for evaluation and treatment and ultimately more DCI cases being reported.

In the meantime, collection efforts continue to improve and provide an effective method of collecting accident forms for review.

This report on 1995 data represents 42.8 percent of the total number of divers treated by reporting hyperbaric facilities.

To report an injury, a fatality, or a near-miss in diving, call the DAN Medical Department.

Divers Alert Network
3100 Tower Boulevard · Suite 1300
Durham, NC 27707
(919) 684-2948

Injured Diver Characteristics

Most of the injury cases continue to occur in the age range from 25 to 44 years; this probably reflects the age range where most of the diving activity occurs.

In this section DAN looks at the various characteristics (age, sex, diving experience, certification level, and more) of the divers in the 1995 DAN accident database. Two points to bear in mind when looking at this data are that not all diving accidents reported to DAN via phone are included in the database, as noted in Section 1; and that since DAN researchers do not know the total numbers of dives performed by all divers, they cannot compare these characteristics to the general diving population. Instead, DAN looks at percentages of the injured diver population, which is then compared to the percentages from earlier years to determine if there are any trends.

The data for the years 1993-1995 are presented individually while the earlier data are presented in three-year increments.

Table 2.1 *Age Distribution of Accident Cases*

Age	1995 Percent	1994 Percent	1993 Percent	90-92 Percent	87-89 Percent
10-14	1.0	0.7	0.8	0.6	0.5
15-19	3.6	3.7	2.2	2.9	2.8
20-24	8.1	8.5	8.8	9.0	9.4
25-29	15.3	20.8	15.4	18.4	22.4
30-34	18.6	17.5	23.2	23.0	22.9
35-39	20.2	15.7	20.4	21.2	16.8
40-44	16.3	15.4	11.4	12.8	12.4
45-49	8.0	9.8	8.3	6.8	6.4
50-54	5.4	4.8	4.7	2.9	3.3
55-59	1.9	2.7	3.0	1.1	1.7
60-64	0.7	0.0	1.2	1.1	1.4
>=65	1.0	0.4	0.6	0.2	0.0
TOTALS	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Age Distribution in Injured Divers

Table 2.1 shows no change in the age distribution of accident cases from previous reporting years. Most of the cases continue to occur to divers in the age range from 25 years to 44 years; this probably reflects the age range in which most of the diving activity occurs. (In a 1996 survey of DAN members, 1.7 percent of respondents indicated that they were younger than 22 years old, and 39 percent of the respondents indicated they were older than 44.)

Table 2.2 *Sex of 1987-1995 Accident Cases*

Sex	1995 Percent	1994 Percent	1993 Percent	90-92 Percent	87-89 Percent
Female	29.7	28.6	31.1	27.0	24.2
Male	70.3	71.4	68.9	73.0	75.8
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

The lower percentages for the "under-24" and the "over-44" cases probably reflect both a lower number of total dives performed by that population, along with avoiding dives which would be more likely to result in accidents.

Sex of Accident Cases

While there was a slight increase in the percentage of females from 1987 to 1992, there has been no significant change since, with approximately 30 percent of cases being female and 70 percent male (Table 2.2, above).

Diver Experience in Injury Cases

The column headings in Table 2.3 (page 26) show the total numbers of lifetime dives as reported by the divers, while the row headings show the number of years of diving. The body of the table shows the number of divers in each category.

In general, male accident victims had more years of diving than females. About 51 percent of all the males had four or more years of experience, while only 31 percent of all female accident victims had comparable experience. Less than 10 percent of the females had 10 years' experience or more, while 30 percent of males had more than 10 years' experience.

Table 2.3 also shows that male accident victims had more total lifetime dives than females. There were 62 percent of females with 40 or fewer lifetime dives, while only 36 percent of males reported that they had done that few dives. Over 44 percent of males had 121 or more lifetime dives while just over 16 percent of females had this high a number.

Overall, dive reporting reflects that females have tended to report accidents after fewer years of diving and after fewer dives. There are several explanations which may account for this observation: one is that females may simply be more prone to diving accidents earlier in their careers and after fewer dives; another possible explanation is that females are more likely to report an injury the first time it occurs, while males will not report it unless it has occurred several times.

In general, male accident victims had more years of diving than females; and females have tended to report accidents after fewer years of diving and after fewer dives.

Table 2.3 *1995 Diver Experience Among Injured Divers*

Male	Total Lifetime Dives							
Years Diving	0-20	21-40	41-60	61-80	81-100	101-120	121+	TOTAL
0-1	74	27	8	5	5	2	4	125
2-3	10	24	10	7	3	4	19	77
4-5	3	4	4	3	6	3	18	41
6-7	1	1	2	1	1	0	21	27
8-9	0	1	0	0	1	0	20	22
10-11	2	1	0	2	2	1	16	24
12-13	0	0	1	0	0	0	21	22
14-15	1	0	0	1	2	0	16	20
16-17	0	0	1	0	0	0	7	8
18-19	1	0	1	1	0	0	6	9
20-21	0	0	0	1	0	1	38	40
TOTALS	92	58	27	21	20	11	186	415

Female	Total Lifetime Dives							
Years Diving	0-20	21-40	41-60	61-80	81-100	101-120	121+	TOTAL
0-1	65	16	5	2	1	0	0	89
2-3	7	9	2	4	3	1	5	31
4-5	1	4	2	2	2	0	9	20
6-7	3	1	0	2	1	1	5	13
8-9	0	0	1	1	1	0	3	6
10-11	1	0	0	0	1	0	2	4
12-13	0	0	0	0	1	0	1	2
14-15	1	1	0	1	0	1	0	4
16-17	0	0	1	0	0	0	1	2
18-19	0	0	0	0	0	0	0	0
20-21	0	0	0	0	1	0	3	4
TOTALS	78	31	11	12	11	3	29	175

Accidents by Years of Diving Experience

Since 1987, there has been a trend for divers with two years' experience or less to report more accidents.

Table 2.4 (page 27) shows a comparison of accidents according to experience level over the years. According to this table, it would appear that there is a trend for divers to report accidents earlier in their careers. Another possible explanation may be that there are simply more newer divers. Since 1987, there has been a trend for divers with two years' experience or less to report more accidents.

The number of accident victims in the two- to five-year category looks relatively stable over the years. This means that the increased reporting in the less experienced group (<two years' experience) is being offset by a decrease in accident reporting by the more experienced divers (≥six years' experience).

One way to account for this trend is that diver education has increased the awareness of diving accidents, especially decompression sickness, and that, overall, divers are more aware of and more likely to report symptoms the first time they experience them. This explanation must remain conjecture until DAN can procure data on the total number of non-accident dives occurring in each of these categories.

Table 2.4 *Number of Injured Divers by Years of Experience*

	1995 Percent	1995 Percent	1994 Percent	1993 Percent	90-92 Percent	87-89 Percent
<2 Years	Male	30.1	25.0	28.3	26.5	19.2
	Female	50.9	49.5	44.9	46.8	39.0
2 to 5 Years	Male	28.4	27.9	24.3	31.6	28.1
	Female	29.1	28.4	35.4	32.9	32.8
6 to 9 Years	Male	11.8	14.6	13.1	12.7	15.6
	Female	10.9	13.6	8.2	9.9	18.2
≥ 10 Years	Male	29.6	32.9	34.3	29.2	37.1
	Female	9.1	7.4	11.4	10.4	9.9

Table 2.5 *Certification Level of 1988-1995 Accident Cases*

Certification	Male	Female	1995 Totals	1995 Percent	1994 Percent	1993 Percent	90-92 Percent	87-89 Percent
Student	3	1	4	0.7	1.9	4.5	1.9	1.3
Basic	39	23	62	10.5	6.4	8.5	7.2	11.6
Open Water	143	85	228	38.6	40.6	39.0	42.5	38.1
Advanced	128	48	176	29.8	26.7	25.6	25.4	25.9
Divemaster	38	7	45	7.6	9.0	7.6	8.0	5.6
Instructor	41	8	49	8.3	12.5	12.4	10.4	10.9
Commercial	3	0	3	0.5	0.0	0.0	0.3	1.3
Other	16	2	18	3.1	1.6	2.2	2.8	1.8
None	4	1	5	0.8	1.2	0.2	1.3	1.2
Unknown	0	0	0	0.0	0.0	0.0	0.2	2.3
TOTALS	**415**	**175**	**590**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Certification Levels in Diving Injuries

In 1995 there has been a decrease among new or infrequent divers in those making square dives and an increase in those diving 80 feet or deeper and reporting a rapid ascent.

As seen in Table 2.5 (page 27), the percentage of students reporting accidents is at its lowest level ever. With a greater emphasis on safety during diver training, one would expect that accidents among student divers would decrease. While there are variations from year to year, there appears to be no trend for *Basic* and *Open-Water* certification categories or for the categories *Divemaster*, *Instructor*, *Commercial*, *Other* or *None*.

This prompts the issue of defining why this upward trend in dive accidents is happening with advanced divers. Are they diving more aggressively, making more deep decompression or cold-water dives? Are they simply more likely to report accidents than in the past, or are there simply more new divers proportionally? These data cannot distinguish between these possibilities, but it will be noteworthy to discover whether the trend continues.

Table 2.6 *New Diver Profile Traits*

Traits	1995 Percent	1994 Percent	1993 Percent	90-92 Percent	88-89 Percent
≤20 Dives	69.7	68.9	78.4	72.0	73.4
Square Dives	48.8	56.9	63.3	50.9	55.2
Repeat Dive	58.0	61.3	62.1	61.6	55.2
Diving ≥ 80 fsw	63.7	55.5	53.0	60.8	52.1
Rapid Ascent	40.0	31.4	32.3	35.6	42.2
Last Dive ≥ 80 fsw	27.6	27.8	24.0	30.3*	0.0
Outside Limits	10.5	10.8+	18.2	22.6	23.4
	n=245	n=213	n=198	n=528	n=192

** from 1992 only*
+ refers to 195 cases

Diving Intensity in Dive Accidents

New- or *Infrequent Divers* are divers who have been diving a year or less or who have 20 or fewer lifetime dives. These are the combined male and female divers shown in the first column and first row of Table 2.3 9 page 26) and accounted for approximately 42 percent of all the injured divers.

In 1995 there has been a decrease in this subset in those making square dives and an increase in those diving 80 feet or deeper and reporting a rapid ascent. The fraction who reported diving outside decompression limits, whether it be tables or computers is essentially unchanged from last year. Sixteen divers where excluded from the outside limits category because they were not using any method to calculate or plan their dive.

Methods of Dive Planning in Accident Victims

Approximately 57 percent (n=337) divers reported using computers, while 37 percent (n=218) reported using tables; 6 percent (n=35) used neither in planning their dives. Approximately 65 percent of both computer divers and table divers who experienced decompression sickness were reported to have DCS II. However, about 30.6 percent of computer divers reported DCS I, while only 21.6 percent of table divers fell into the same category.

About 12.8 percent of Table divers experienced AGE, while only 4.7 percent of computer divers did. One conclusion which could be drawn from these data is that rate-of-ascent indicators on dive computers are better at keeping divers from ascending too fast than judgment methods (e.g., not ascending faster than your bubbles) used by table divers. Of the divers who did not use any method of dive planning, 80 percent had Type II DCS, 14.3 percent had DCS I and 5.7 percent had AGE. It would appear that using some method to determine decompression requirements may reduce the likelihood of DCS II occurring, if DCS occurs at all.

Approximately 65 percent of both computer divers and table divers who experienced decompression sickness were reported to have Type II symptoms.

Table 2.7 *Current Medical History of DCI Cases for the Years 1988-1995*

Problem	1995	1994	1993	90-92	88-89
None	433	430	396	994	462
Other	52	37	55	125	87
GI/Abdomen	16	15	15	37	13
Spine/Back	24	24	13	51	29
Muscl/Skel System	12	14	7	54	23
Chest-lung	10	10	7	37	13
Asthma	17	14	5	21	11
Cir/Blood	2	11	5	12	9
Mental/Emotion	12	9	4	27	12
Neuro/Nerv System	2	8	4	17	4
Chest-heart	7	4	4	12	10
Eye	5	3	4	6	5
Limb/Joint DCS	12	6	1	16	5
Brain	1	1	1	2	-
No response	0	0	1	1	0
TOTALS	**605***	**586***	**522***	**1412***	**683***

** Some divers reported multiple health problems.*

Current Medical History in Divers With DCI

Table 2.7 shows the organ systems affected in those divers who reported medical problems. Unfortunately, there are no details in the database regarding the exact nature of the disease or condition. The number of divers experiencing accidents who reported having

Table 2.8 *Percentage of Divers Without Current Health Problems*

Current	1995	1994	1993	90-92	87-89
Frequency	433	430	396	994	636
Percent	74.4	76.0	78.0	75.0	68.5

asthma as a fraction of all reported accidents was 2.5 percent for 1994 and 2.9 percent for 1995, essentially unchanged. Since DAN does not have any good estimates of the total number of asthmatic divers, it not possible to say if asthma is a risk factor for DCI.

Table 2.8 (above) shows that the percentage of accident victims without current medical problems has remained fairly constant since 1990 at 75-78 percent.

Table 2.9 *Previous Illness and Diseases of Decompression Illness Cases for the Years 1988-1995*

Problem	1995	1994	1993	90-92	88-89
None	297	320	250	664	313
Other	101	81	81	203	108
Muscl/Skel System	49	52	59	169	83
Spine/Back	48	39	44	130	58
GI/Abdomen	56	43	43	129	69
Limb/joint DCS	35	28	24	101	25
Asthma	27	21	18	49	30
Chest-heart	17	10	15	34	17
Chest-lung	14	17	13	57	28
Eye	14	17	12	25	11
Mental/Emotion	8	7	7	22	5
Neuro/Nerv System	9	12	6	33	8
Brain	3	5	6	12	5
Cir/Blood	8	6	5	17	10
No Response	0	0	2	1	0
TOTALS	**686**	**658**	**585**	**1646**	**770**

Table 2.10 *Percentage of Divers Without Past Health Problems*

Current	1995	1994	1993	90-92	87-89
Frequency	297	320	250	664	444
Percent	50.3	56.5	49.2	46.0	47.8

Past Medical Problems in Divers with DCI

Table 2.9 (page 30) shows that the spectrum of past medical problems among accident victims according to organ system has not changed significantly since 1993. Table 2.10 (page 30) shows that since 1993 about half of the divers experiencing DCI reported no past medical problems, with little evidence of a trend over the years.

Physical Fitness in Divers With DCI

Divers with DCI were asked to self-evaluate their degree of physical fitness, and as can be seen in Table 2.11 (above), about 90 percent said they were physically fit. Unfortunately, there were no separate objective criteria used to substantiate these claims (frequency and type of daily exercise, etc.) so it is hard to draw any conclusion as to how physical fitness affects the likelihood or severity of DCI.

About 90 percent of the divers reporting DCI said they were physically fit, but there were no separate objective criteria used to verify these claims.

Table 2.11 *Reported Physical Fitness in Injured Divers*

Sex	1995 Percent	1994 Percent	1993 Percent	90-92 Percent	88-89 Percent
Male	88.4	92.6	92.9	91.2	91.0
Female	89.7	89.5	91.8	88.3	87.0
TOTAL	**88.8**	**91.7**	**92.5**	**90.4**	**90.0**

Medication Use in Injured Divers

The most common drug reported was for analgesics/nonsteroidal anti-inflammatories (17 percent), followed by birth control medication (16 percent) and decongestants (12 percent). Next most frequently reported were psychotropics (6 percent), antiulcer medications (6 percent), antihypertensives (5 percent), antibiotics (5 percent), antihistamines (3 percent), estrogens (3 percent) and anti-motion sickness medications (3 percent).

Table 2.12 *Medication Use in Accident Cases*

	Prescription Use		Nonprescription Use	
Year	Frequency	Percent	Frequency	Percent
1995	175	29.7	93	15.8
1994	172	30.4	85	16.3
1993	129	26.4	71	17.4
1990 - 1992	372	28.0	234	20.0
1988 - 1989	151	23.6	96	16.3

Table 2.13 ***Percentage of Alcohol Use in 1988-1995 Accident Cases***

Time of Use	1995	1994	1993	90-92	88-89
Night before	38.6	37.1	41.9	38.1	41.8
Pre-dive	1.0	1.1	1.4	1.4	1.7
Between dives	1.7	0.7	1.2	1.5	2.3
Post-dive	15.3	15.4	15.7	14.5	13.5
None	52.9	56.0	50.8	55.2	49.7
	n=590	*n=566*	*n=508*	*n=1358*	*n=659*

**Some divers engage in drinking at more than one time before and/or after diving.*

Alcohol Use In Accident Cases

Table 2.13 (above) shows that both the time of alcohol use and the number of divers abstaining has remained fairly constant over the years. Because alcohol is a diuretic, it would tend to dehydrate divers, but that would only occur if no water or other fluids were consumed prior to the dive to counteract the effect.

In addition, alcohol would affect performance and thinking, but there are no measures of this in DAN's database. About 2.7 percent of divers reported drinking just before diving or between dives. Unfortunately, the number of drinks consumed during these time periods is not available.

Nausea and hangover are two likely outcomes of excessive alcohol consumption, but only 29 divers (4.9 percent) reported either symptom on the day of the dive, as shown in Table 2.14 (page 33). Given that about 39 percent of divers reported consuming alcohol either the night before, predive or between dives, then a maximum of 13 percent of the divers would have had symptoms which could have been related to excessive consumption.

The most common prescription drug reported by injured divers was for analgesics/ non-steroidal anti-inflammatories, followed by birth control medication and decongestants.

However, given that details of these predive conditions where not provided, it cannot be automatically assumed that all of these symptoms were alcohol-related. Table 2.14 (above) shows that eight cases of predive diarrhea were reported, which represents 1.4 percent of all DCI cases. Diarrhea may lead to dehydration, which is thought to be a risk factor in DCI. Again, the severity of any predive dehydration was not evaluated, so it is difficult to draw any firm conclusions about the impact of this condition on DCI severity.

In past reports, DAN has shown the number of divers who reported recreational drug use. However, given the social and legal implications of such usage, it is likely that these numbers do not reflect the true incidence. With no independent measures of recreational drug use among accident victims, DAN has decided to not report in this category.

Table 2.14 *1995 Nausea, Hangover and Diarrhea*

Sex	Nausea	Hangover	Diarrhea
Male	9	9	9
Female	9	2	10
Totals	**18**	**11**	**19**

Summary

- Male accident victims tend to have more years of diving experience and more total lifetime dives than females.

- The percentage of accident victims who are student divers seems to be decreasing each year since 1993, while the percentage of advanced divers seems to be increasing.

- Divers who reported using dive computers were less likely to suffer AGE than divers using tables.

DAN no longer reports the use of recreational drug use among divers, because there are no independent measures of recreational drug use among accident victims.

Dive Profile / Incidents

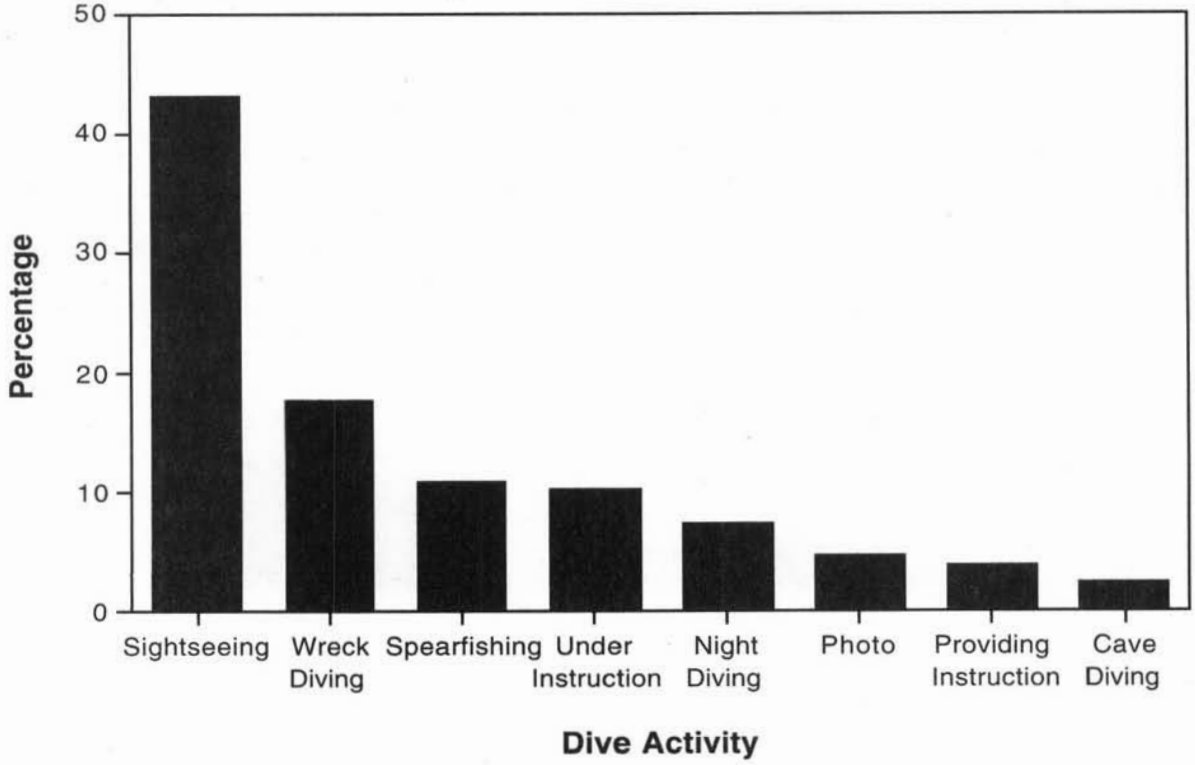
Very few accidents occurred among instructors in a teaching setting (3.9 percent), while students receiving instruction have a higher incident of accidents (10.3 percent).

Dive Activities

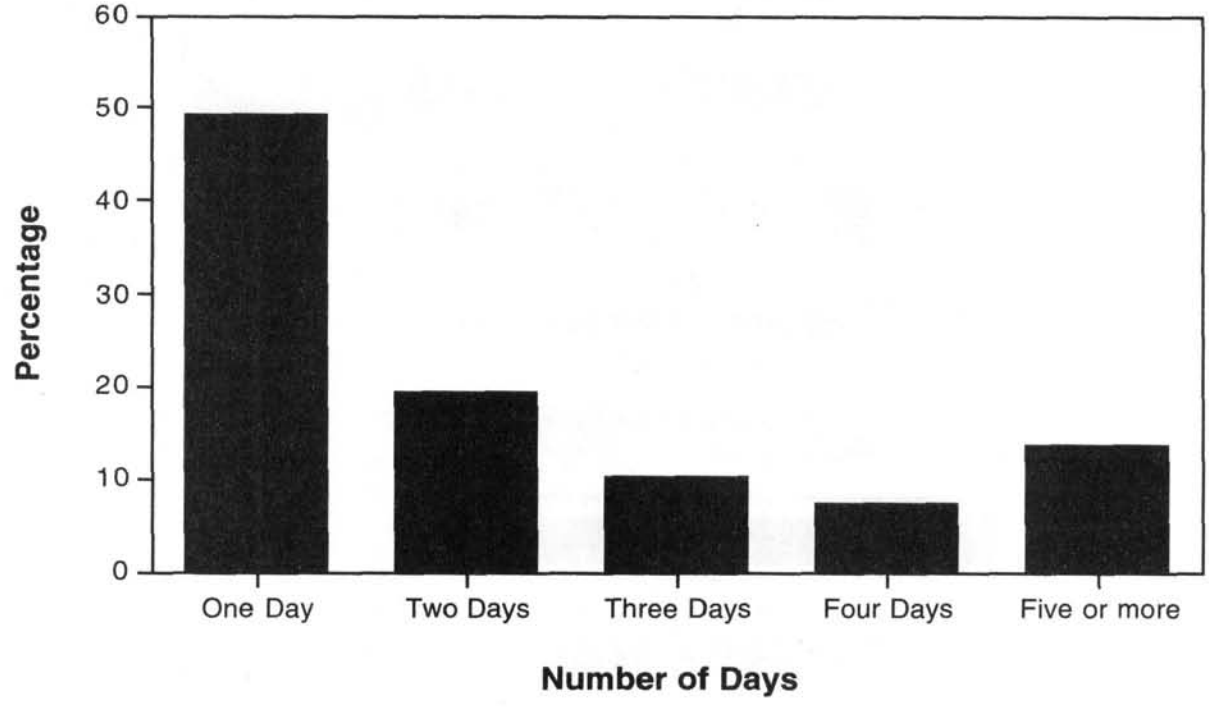
The dive profile section is meant to demonstrate the type of underwater activity being performed, as well as various attributes of the dives at the time of a DCI incident. The dive profile information is limited and can only be considered in relation to the various attributes of dives recorded by DAN. In the future, more accurate dive profile information will be available from Project Dive Safety, through computer records of time and depth reporting.

A total of 43.1 percent of all incidents occurred while sightseeing; the second most common activity associated with diving accidents was wreck diving (Graph 3.1, below). Very few accidents occurred among instructors in a teaching setting (3.9 percent), while students receiving instruction have a higher incident of accidents (10.3 percent) than instructors teaching them. Cave diving incidents which result in DCI were very low (2.3 percent) in the 1995 data.

Graph 3.1 *Primary Dive Activity*



Graph 3.2 ***Number of Days of Continuous Diving***



Number of Days Diving

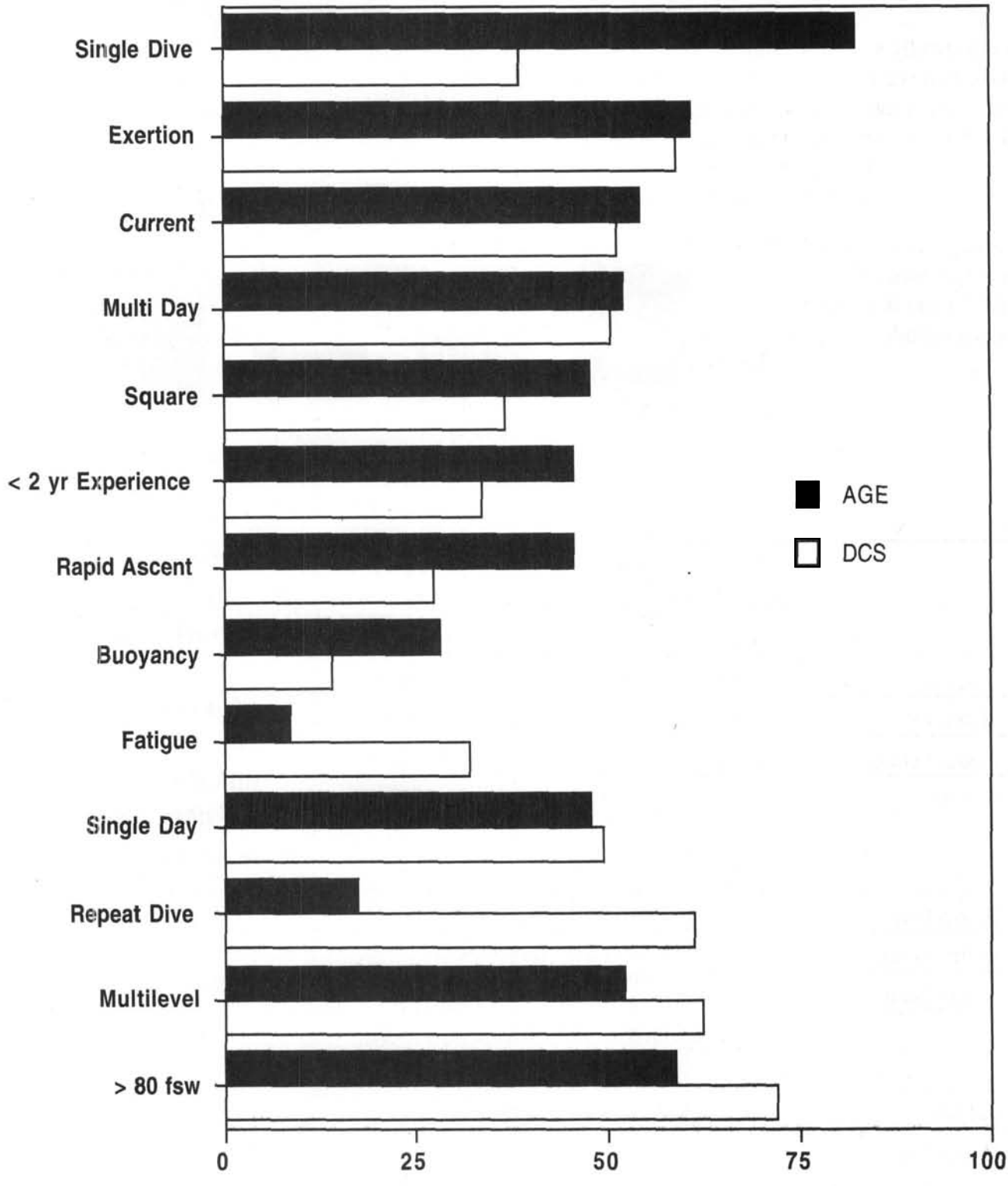
Graph 3.2 (above) shows that in 1995, almost half of all injured divers suffered their accident during a single-day dive program (49.3 percent). This has been a consistent trend in accident reporting over the last several years. Further analysis of the single-day diving group revealed that 59.8 percent were more frequent divers making over 20 dives per year, and 70 percent had completed a dive in the last 30 days. Only 35.2 percent of those divers with less than or equal to two years of diving experience or 20 or fewer dives were also injured on the first day of diving. Less frequent divers and those with a lesser amount of experience are not extensively represented in single-day DCI injuries.

One notable change in the dive injury data for 1995 was that in single-day diving there were fewer cases of both arterial gas embolism and decompression sickness. Overall, more injuries occurred after the first day of diving. Fifty percent of injuries were reported after two or more days of diving, and only 13.6 percent of divers were injuries associated with a series of five days or more.

In this small group of divers who dived five or more days, 72.8 percent experienced DCS symptoms involving the nervous system (DCS II). This is a higher incidence of neurological symptoms than that of the entire group and may be due to the increased nitrogen exposure this group experienced. Measures to decrease exposure time may prevent DCS in this group, such as limiting dive depth and times, total number of dives or sitting out a day of diving.

The 1995 database reveals there were both fewer arterial gas embolism cases and decompression sickness cases in single-day diving

Graph 3.3 *Percentage of DCS and AGE Dive Characteristics*



Dive Characteristics of DCS and AGE

Tables 3.1 and 3.2 (pages 37-38) show characteristics of dives that result in both types of decompression illness — decompression sickness and arterial gas embolism. The attributes of these dives were broadly similar, but differences are noted among them due to the difference in classification used by some of the network chamber facilities. A more standardized reporting format is currently being developed to accurately describe symptoms, enhance diagnosis and assist in classification, and reduce uncertainty. These data are recorded as reported by the treating facility.

As in previous years, DCS cases (544) were reported in greater numbers than AGE cases (46). The two different final diagnoses (DCS I and II vs. AGE) have several similar dive characteristics, which include no-decompression diving, diving within the limits of the tables or computer used and being associated with physical exertion.

Fifty percent of DCI injuries were reported after two or more days of diving, and only 13.6 percent of divers were injuries associated with a series of five days or more.

Table 3.1 *Characteristics of Dives that Resulted in DCS*

Attribute	1995 Percent	1994 Percent	1993 Percent	1990-1992 Percent	1987-1989 Percent
No Decompression	85.1	83.2	78.9	80.0	78.5*
≥ 80 fsw	72.1	71.2	70.8	64.5	74.6*
Multilevel	62.5	57.9	50.5	64.1	51.9*
Repeat Dive	61.2	61.8	63.6	68.2	52.9
Exertion	59.2	54.0	59.7	49.3	29.8
Current	51.3	46.6	54.5	50.5	40.7
Multi Day	50.6	52.8	53.2	48.7	51.0*
Single Day	49.4	47.2	46.6	51.3	53.3
Within Limits	39.7	86.9	46.0	65.4	56.5
Single Dive	38.8	38.2	36.2	32.6	32.7*
Square	36.8	39.9	36.2	35.8	42.8*
< 2 yr. Experience	33.8	30.1	32.2	30.9	26.1
Fatigue	32.2	30.7	29.0	34.5	34.1
Rapid Ascent	27.4	21.5	21.8	21.9	24.3
Buoyancy	14.1	12.3	11.1	11.6	13.6

**These percentages are from 1989 only.*

Common traits of a classic DCS case in the DAN accident database show repetitive dives at multiple levels.

In recent years, rapid ascent has been one of the risk factors associated with AGE (45.7 percent) and may also be a factor in DCS I and DCS II. However, in 1995 rapid ascent is less frequently mentioned as a dive characteristic among divers with a DCS injury (27.4 percent). DCS usually results from a prolonged exposure at a depth of 30 feet / 9 meters or greater. Rapid ascents and time at depth both can contribute to bubble formation. The field management and treatment of an injured diver is the same regardless of the mechanism of injury. Comparisons of Tables 3.1 (page 37) and 3.2 (below) reveal the differences in the various characteristics of both AGE and DCS cases. Most recreational diving does not require mandatory decompression stops, and no-decompression diving is not included in Graph 3.3. Comparisons can be made using Tables 3.2 and 3.3.

DCS Characteristics

Common traits of a classic DCS case in the DAN accident database show repetitive dives at multiple levels. It was also most likely to be part of a multiday dive series and have several dives to greater than 80 feet / 24 meters. A good percentage of divers, as shown before, had more than two years of dive experience.

Table 3.2 *Characteristics of Dives that Resulted in AGE*

Attribute	1995 Percent	1994 Percent	1993 Percent	1990-1992 Percent	1987-1989 Percent
No Decompression	91.3	92.7	87.8	68.1	92.3*
Single Dive	82.6	72.7	61.0	70.1	67.3*
Within Limits	67.4	96.0	59.2	90.4	80.0
Exertion	60.9	65.5	49.0	41.9	19.3
≥ 80 fsw	58.7	47.3	44.9	49.4	46.2*
Current	54.3	61.8	42.9	45.5	32.6
Multi Day	52.2	40.0	44.9	32.1	46.2*
Multilevel	52.2	40.0	22.4	41.7	35.5*
Single Day	47.8	60.0	55.1	67.9	48.6
Square	47.8	58.2	59.2	58.3	55.8*
Rapid Ascent	45.7	52.7	55.1	56.3	52.0
< 2 yr. Experience	45.7	40.0	44.9	35.7	49.3
Buoyancy	28.3	18.2	38.8	28.6	21.3
Repeat Dive	17.4	27.3	30.6	29.9	29.3
Fatigue	8.7	21.8	22.4	13.1	29.3

**These percentages are from 1989 only.*

AGE Characteristics

The typical AGE incident from the DAN accident database occurs within the limits of the table or computer used, and as part of a single dive and single-day series. A total of 45.7 percent of individuals with AGE claimed to have made a rapid ascent, a predominant factor in a diagnosis of AGE. Cases of AGE tend to involve a lesser percentage of multilevel and deep dives to greater than 80 feet / 24 meters than those diagnosed as DCS.

Only 17.4 percent of AGE divers were making repetitive dives, which fits the classic scenario. The diagnosis of AGE or DCS may be influenced by a knowledge of the dive profile and is usually taken

Cases of AGE tend to involve a lesser percentage of multilevel and deep dives to greater than 80 feet than those diagnosed as DCS.

Table 3.3 *Computer and Table Divers with Decompression Illness*

	Computer Users				
	1995 Percent	1994 Percent	1993 Percent	1990-1992 Percent	1987-1989 Percent
DCS I	30.7	27.8	27.1	23.5	30.0
DCS II	64.7	66.1	66.9	69.6	62.0
AGE	4.7	6.1	6.0	6.7	8.0
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
	n = 337	*n = 313*	*n = 266*	*n = 626*	*n = 251*

	Table Users				
	1995 Percent	1994 Percent	1993 Percent	1990-1992 Percent	1987-1989 Percent
DCS I	21.6	22.9	18.6	15.4	17.5
DCS II	65.6	62.8	67.8	67.6	63.2
AGE	12.8	14.2	13.6	17.0	19.3
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
	n = 218	*n = 218*	*n = 242*	*n = 735*	*n = 668*

	Neither Computer or Table	
	1995 Percent	1994 Percent
DCS I	14.3	20.0
DCS II	80.0	65.7
AGE	5.7	14.3
TOTAL	**100.0**	**100.0**
	n = 35	*n = 35*

into account in AGE cases. A short dive with minimal gas uptake weighs in favor of AGE rather than DCS.

Diving "within limits" increased in both AGE and DCS cases. This was in part due to the removal of a small group of divers who were considered separately because they chose to dive without using a computer or dive tables. Additionally, in earlier reports there were fewer computer users, and divers may have been considered "outside limits" if they were not within both computer and table limits. In this report, as with last year's report, each group is considered separately.

The incidence of neurological DCS (DCS II) for computer divers, table divers, and in divers who used neither was broadly similar.

Dive Computer Use

In 1995, 337 (57 percent) of injured divers used dive computers. The breakdown of DCI into the historical categories of DCS I, II and AGE seen in Table 3.3, is separated into computer users, table users and divers who used neither. Approximately 6 percent of divers (35) apparently used neither computers nor tables. The incidence of neurological DCS (DCS II) for computer divers, table divers, and in divers who used neither was broadly similar.

Although the "neither" group is small, it is notable that DCS II occurred in 80 percent of this group. Arterial gas embolism cases were down among all divers but still highest among table users, where AGE represented 12.8 percent of table users, almost three times the percentage of AGE cases in computer users. Table divers had lower DCS I than computer users.

Table 3.4 *Attributes of Computer Divers From 1987-1995*

Attribute	1995 Percent	1994 Percent	1993 Percent	1990-1992 Percent	1987-1989 Percent
Within Limits	93.8	91.1	64.9	59.1	32.7
≥ 80 fsw	77.7	78.1	79.1	73.1	86.5
Repeat Dive	77.4	82.6	82.1	69.0	63.7
Multilevel	76.0	74.6	77.7	78.8	71.4
Exertion	59.6	54.9	61.5	48.4	29.9
Current	51.0	45.8	54.9	48.9	43.8
Single Day	50.7	44.7	48.3	51.2	50.6
Multi Day	49.3	55.3	51.7	48.6	53.2*
Fatigue	29.4	28.5	28.3	32.5	31.0
Decompression	17.8	22.8	24.3	24.5	32.7
Outside Limits	6.2	7.0	35.1	40.9	39.4

**These percentages are from 1989 only.*

Tables 3.4 and 3.5 show the attributes of both table and computer divers. By their own admission, 6.2 percent of computer divers were outside of their computer limits. The percentage of table divers outside the tables was 13.3 percent. The within limits/outside limits fields were based on whether the diver was outside the limit of the respective device they used (computer or table). The 35 individuals who used neither computers or tables were excluded from Tables 3.4 and 3.5. This exclusion, as previously noted, caused the percentage of injured divers within limits to increase.

Table 3.5 ***Attributes of Table Divers From 1987-1995***

Attribute	1995 Percent	1994 Percent	1993 Percent	1990-1992 Percent	1987-1989 Percent
Within Limits	86.7	82.6	73.1	74.4	70.5
Repeat Dive	63.3	73.4	78.5	58.8	51.0
Exertion	61.0	56.0	57.0	49.7	27.4
Multi Day	57.3	47.7	53.3	44.7	49.1*
Current	54.1	45.4	52.1	50.5	37.8
≥ 80 fsw	48.6	57.3	57.0	53.7	63.4*
Single Day	42.7	52.3	46.7	54.6	53.2
Multilevel	39.4	36.7	28.1	45.9	45.3*
Fatigue	28.4	33.0	29.8	31.4	34.2
Outside Limits	13.3	17.4	17.8	25.6	28.7
Decompression	11.9	10.6	11.2	13.2	20.2

**These percentages are from 1989 only.*

In nearly 18 percent of cases, computer divers had engaged in dives requiring decompression stops, whereas table divers planned their decompression stops in only 12 percent of cases. It is recommended by most of the computer manufacturers that computers not be used for planned decompression stage diving. As expected, multilevel dives were performed by 76 percent of computer divers but only by 39 percent of table divers. This difference is expected, because dive computers allow for multilevel diving in their algorithms without the bottom time restrictions imposed by tables.

The 35 divers who used neither computers nor tables tended to follow no device and apparently followed their buddies or dive-masters. These individuals dived deeper than 80 feet in 54.3 percent of cases, made multiday dives in approximately 60 percent of cases and repetitive dives in 22.9 percent (Table 3.6, page 42).

In 1995, AGE was still higher among table users, (12.8 percent), almost three times the percentage of AGE cases in computer users (4.7 percent).

Table 3.6 ***Attributes of Divers Using Neither Computer nor Tables***

Attribute	1995 Percent	1994 Percent
Multilevel	62.9	57.1
Multi Day	60.0	42.9
≥ 80 fsw	54.3	65.7
Exertion	48.6	62.9
Current	42.9	88.6
Single Day	40.0	57.1
Fatigue	37.1	28.6
Repeat Dive	22.9	51.4
Decompression	14.3	2.9
	(n = 35)	*(n = 35)*

The DAN database showed that computer users were more experienced divers, and had been diving more often and for a greater number of years than table users

The DAN database revealed that computer users were more experienced divers, and had been diving more often and for a greater number of years than table users. There was little difference between groups in the number of divers who ran out of air (5.0 percent of table users and 3.6 percent of computer users). In the group who used neither computer or tables, no one ran out of air, while 17.1 percent ran low on air. A total of 7.1 percent of computer users were low on air, compared to 15.6 percent of table users.

Equipment

Scuba diving is an activity that requires knowledge and familiarity with the equipment used, as well as adequate maintenance of that equipment. Correct functioning of the equipment and the knowledge of how to use it safely are essential to safe diving. Of the cases outlined in the 1995 report, 13.1 percent involved reporting equipment problems (Table 3.7, page 43).

The number of accidents related to equipment problems has remained low over the years. The fact that an equipment problem was reported does not necessarily mean that the equipment failure caused the incident but merely that the diver recognized a problem. The most common equipment problem reported in both AGE and DCS cases was unfamiliarity with equipment. Those divers with DCI who reported an equipment problem were most likely to have reported trouble with a regulator, buoyancy compensator vest, or weight belt. Over half of the divers with AGE and equipment difficulties reported a problem with their regulator or air supply or were unfamiliar with their gear. Some divers also listed "other" problems which in some way influenced their dive profile. These included mask problems (3), depth or pressure gauge problems (7), problems with the scuba tank (1) and problems with the wetsuit (1).

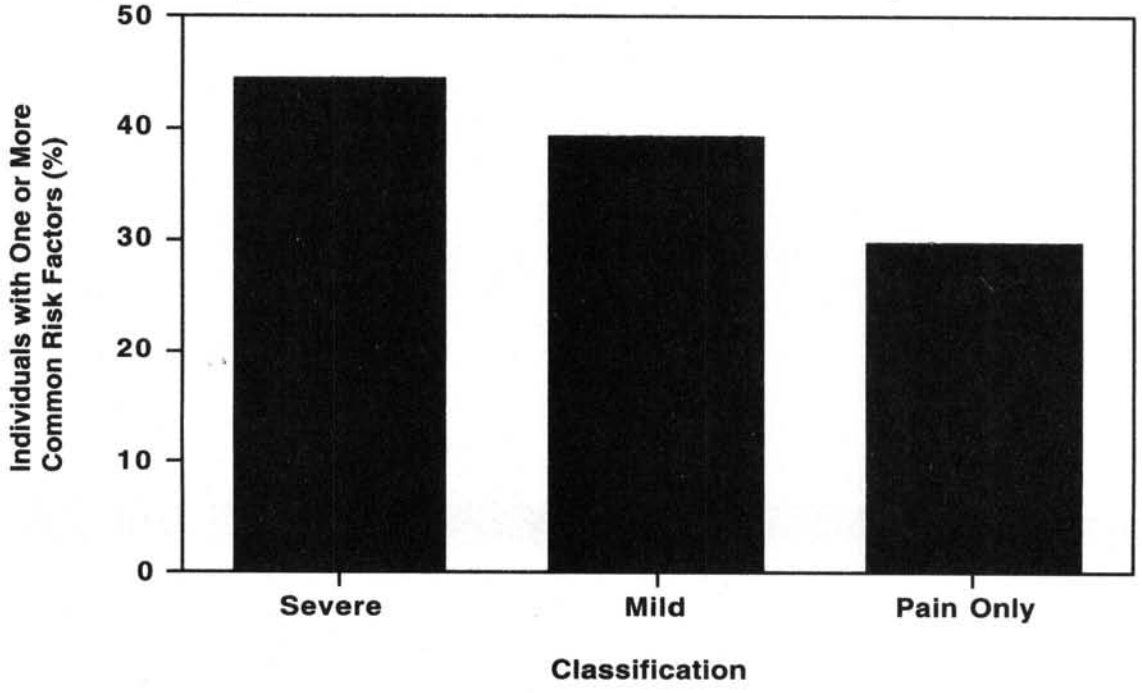
Table 3.7 *1995 Equipment Problems*

Equipment	Frequency	DCS	AGE
BC Vest	11	10	1
Unfamiliar Equipment	18	12	6
Regulator	14	9	5
DC Computer	4	4	0
Inflator Hose	0	0	0
Weight Belt	12	10	2
Dry Suit	4	4	0
Contaminated Air	1	0	1
Other	13	11	2
TOTALS	**77**	**60**	**17**

Common Risk Factors

Thirty-nine percent of the divers in the 1995 accident database reported experiencing one or more of four of the following problems on the day of their accident: rapid ascent, buoyancy problems, equipment problems, going outside limits. Graph 3.4 (below) shows the percentage of these individuals broken down by the presenting symptom classification (Chapter 4).

Graph 3.4 *Common Risk Factors in Decompression Illness*



Thirty-nine percent of the divers in the 1995 accident database reported experiencing one of four of the following problems on the day of their accident: rapid ascent, buoyancy problems, equipment problems, & going outside limits.

Summary

- Decompression illness was reported by both frequent and infrequent divers.

- AGE-related cases are characterized by single-day, single-dive, square profiles, and are associated with a rapid ascent in 53 percent of all AGE injuries, compared to 27.4 percent in DCS-related cases.

- DCS-related cases are characterized by divers who tend to have more experience and engage in multiday, deeper repetitive dives. In AGE cases, this diving pattern was not observed as often.

- A majority of injured divers stated they stayed within the limits of their tables or computer, but 6 percent of all divers did not use any means of dive planning.

- Among injured divers, computer users tend to be more experienced divers and now make up 57.1 percent of the divers reported on each year.

- Equipment problems were associated with 13 percent of the DCI cases. The largest percentage (approximately 23 percent) of these involved unfamiliarity with equipment. This suggests a need for better understanding and care of diving equipment.

Symptoms of DCI

Frequency Distribution of Symptoms

The frequency of occurrence of the various symptoms of decompression illness (including all cases of both AGE and DCS) is shown in Table 4.1 (page 46). DCI often consists of several different symptoms developing over a period of time; thus, the occurrence with which a symptom is the first (presenting) symptom may be different from the total occurrence of that symptom. Total occurrence represents the number of times a symptom appeared in the entire injury population.

As in 1994, pain was the most frequent first symptom of DCI, occurring in approximately one-third of the cases, while nearly 60 percent of divers with DCI experienced pain at some time in their illness. The second most frequent symptom was numbness, as demonstrated in one-fifth of cases, which occurred at some point in over 60 percent of cases.

In Table 4.1, the shaded "total" lines represent actual occurrence of symptoms within the given classification of severe or mild neurological symptoms and pain/skin/nonspecific symptoms. For example, the totals for pain/skin/nonspecific symptoms represent the total occurrence of pain as a first symptom among all classifications (n=326), and the number of times pain occurred without any neurological symptoms (n=104).

Neurological symptoms have been classified as either serious or mild. While weakness could be classified as a serious symptom, it is an ambiguous term since it can be interpreted as either frank (unmistakable) motor weakness, or a vague feeling of generalized malaise. Certain symptoms such as hearing loss and tinnitus (ringing in ears), while serious, have not been listed as severe neurological symptoms, because they can be manifestations of otic barotrauma and cannot be definitively ascribed to decompression illness. Similarly, difficulty breathing is ambiguous in that it may be a manifestation of anxiety, pulmonary barotrauma or aspiration of water.

While 39 percent of divers with DCI had a neurological symptom as an initial symptom, 82.4 percent of divers ultimately developed one. Only 2.7 percent of divers with DCI initially showed severe symptoms, but one-quarter (146 divers) had severe symptoms at some time. The development of neurological symptoms when only pain or fatigue were present initially, and the progression from mild symptoms to severe ones, suggest that neurological or severe symptoms might be preventable with early treatment.

As in 1994, pain was the most frequent first symptom of DCI, occurring in approximately one-third of the 1995 cases.

Table 4.1 *1995 Most Frequent Symptoms of Decompression Illness*

			First Symptom		Total Occurrence	
			N	Percent	N	Percent
Neurological	Severe	Unconsciousness	4	0.7	15	2.5
		Paralysis	3	0.5	22	3.7
		Visual disturbance	5	0.8	39	6.6
		Difficulty walking	2	0.3	55	9.3
		Semi-consciousness	1	0.2	13	2.2
		Bowel problem	1	0.2	17	2.9
		Speech disturbance	0	0.0	16	2.7
		Bladder problem	0	0.0	11	1.9
		Convulsions	0	0.0	0	0.0
Total Severe Neurological Symptoms			**16**	**2.7**	**146**	**24.7**
Neurological	Mild	Numbness	129	21.9	364	61.7
		Dizziness	44	7.5	134	22.7
		Decreased skin sensation	1	0.2	39	6.6
		Personality change	1	0.2	14	2.4
		Reflex change	1	0.2	3	0.5
		Weakness	38	6.4	150	25.4
Total Mild Neurological Symptoms			**214**	**36.3**	**340**	**57.6**
Total Neurological Symptoms			**230**	**39.0**	**486**	**82.4**
Pain/skin/nonspecific		Pain	203	34.4	341	57.8
		Extreme fatigue	25	4.2	124	21.0
		Headache	35	5.9	146	24.7
		Nausea	25	4.2	87	14.7
		Itching	21	3.6	53	9.0
		Rash	5	0.8	25	4.2
		Restlessness	6	1.0	38	6.4
		Muscle twitch	5	0.8	33	5.6
		Hemoptysis	1	0.2	6	1.0
Total Pain/Skin/Nonspecific Symptoms			**326**	**55.3**	**104**	**17.6**
Ambiguous		Hearing loss	3	0.5	8	1.1
		Ringing in ears	1	0.2	14	2.4
Cardiorespiratory (CR)		Difficulty breathing	8	1.4	47	8.0
Other		Stiffness	2	0.3	9	1.5
		Hot/cold flashes	2	0.3	6	1.0
		Cramps	1	0.2	5	0.8
		Swelling	5	0.8	7	1.2
		Pressure sensation	2	0.3	4	0.1
		Lightheaded/confusion	1	0.2	16	2.7
		Fullness	1	0.2	2	0.3
		Muscle ache/soreness	4	0.7	6	1.0
		Bleeding	1	0.2	3	0.5
		Ear blockage	1	0.2	2	0.3
		Erratic heartbeat	1	0.2	2	0.3
		Coughing	1	0.2	2	0.3
Total Ambiguous/CR/Other Symptoms			**34**	**5.8**	**133**	**22.5**
		Total	**590**	**100.0**	**590**	**100.0**

Table 4.2 *Traditional Classification of DCS Symptoms*

DCS-I	DCS-II
Pain	Neurological
Fatigue	Cardiorespiratory
Skin	
Lymphatic	

Table 4.3.1 *Conventional Disease Diagnosis*

Final Diagnosis	1995 Percent	1994 Percent	1993 Percent	90-92 Percent	87-89 Percent
DCS-I	27.3	25.4	23.0	19.3	21.0
DCS-II	64.9	64.8	67.4	68.3	63.0
AGE	7.8	9.7	9.6	12.4	16.0
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table 4.3.2 *Classification by Type of Symptom*

Symptom Type	1995 Percent	1994 Percent	1993 Percent	91-92 Percent	89-90 Percent
Severe Neurological	24.7	27.0	25.8	32.7	27.3
Mild Neurological	57.6	54.2	58.5	47.3	52.6
Pain Only	17.6	18.7	15.7	20.0	20.1
TOTALS	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
	n=590	*n=566*	*n=508*	*n=902*	*n=850*

These observations provide support for the recommendation that all divers with symptoms of DCI should obtain early evaluation and treatment.

Traditionally DCI has been classified into:
- arterial gas embolism (AGE) — gas bubbles in the vascular (arterial) system due to pulmonary overpressurization; and
- decompression sickness (DCS) — the formation of gas within tissues and bloodstream due to too rapid an ascent from diving with a compressed gas. DCS has been further classified into Type I, or DCS I; and Type II, or DCS II (Table 4.2, top).

The distributions of conventional diagnoses are shown in Table 4.3.1 (above). The differentiation of AGE and the two forms of DCS was previously believed to be important because the classification dictated the form of recompression treatment.

DAN recommends that all divers with symptoms of DCI get early evaluation and treatment.

It is often possible to differentiate between these diagnoses. For example, a diver who makes a shallow dive for a minute or two and then is observed to surface while holding his breath or making a panic ascent — after which he loses consciousness and has a convulsion — is most likely to have AGE.

Alternatively, when a diver who has a deep dive profile and enough time to develop a significant inert gas load experiences joint pain two hours after surfacing, that diver most likely has DCS.

Many dive physicians feel that the treatment table should be dictated more by clinical response to treatment rather than by the dive history.

In many instances, however, it is impossible to make an accurate differentiation because contributing factors, such as the rate of ascent or breath-holding, may not have been observed. Additionally, a diver may have had a depth-time profile sufficient to develop DCS and an ascent likely to produce AGE. Moreover, many dive physicians feel that the treatment table should be dictated more by clinical response to treatment rather than by the dive history.

Because of its widespread use, the traditional classification as assigned by the treating physician is reported in addition to the individual symptoms.

Errors in Classification

Analysis of subgroups of Table 4.1 reveals that many divers assigned the diagnosis of DCS I had symptoms which should have led to their classification as DCS II (Table 4.4). Of 161 divers classified by the treating physician as DCS I, 97 reported neurological complaints (60 percent of divers diagnosed with DCS I, and 16 percent of all divers). Of these divers, 20 were classified as severe (12 percent of divers diagnosed with DCS I and 3.3 percent of all divers).

Of the 486 divers who had neurological complaints, 20 percent were incorrectly classified by the person filling out the form as DCS I; of the 146 divers with severe neurological complaints, 13.7 percent were similarly misclassified as DCS I. The reason for this is unknown, but it may be due to either unfamiliarity of the treating physician with the classification scheme; or perhaps it could be failure of the diver to report neurological symptoms to the treating physician.

Difficulties such as this have led to the recent emphasis on individual symptoms or symptom clusters as better predictors of outcome than the traditional scheme. Work to develop better outcome predictors is ongoing. The classification into mild and severe symptoms outlined in Table 4.1 represents a preliminary approach.

Despite the errors in classification, the reported numbers reflect the diagnosis assigned by the treating physician. The proportion of divers in each diagnostic category remains unchanged from 1994. The continued decrease in the proportion of AGE cases observed from 1987 (when 19.3 percent of the reported cases were due to AGE) to 1995

(7.8 percent of cases diagnosed as AGE) could be due to several factors, including a gradual change in the criteria by which the diagnosis of AGE is assigned or selective reporting of AGE in the earlier years of data collection.

Alternatively, it may be due to better ascent training, greater use of decompression computers with ascent rate alarms and perhaps a true reduction in the proportion of dive accidents due to gas embolism. These possibilities cannot be distinguished on the basis of available DAN data.

Despite this time-related change in diagnosis, there has been no parallel change in symptom severity (see Table 4.3.2 on page 47).

Table 4.4 *Symptom Types Found in Traditional Classifications of DCI*

Symptom Type	DCS-I	DCS-II	AGE
Severe Neurological	20	97	29
Mild Neurological	77	248	15
Pain Only/Nonspecific	64	38	2
TOTALS	**161**	**383**	**46**

Symptom Onset Time

Symptom onset time is shown in Table 4.5. Because the distribution of onset times is not symmetrical, the typical onset time is best estimated by the median (time at which 50 percent of divers have become symptomatic), rather than the mean. Interestingly, the onset times of DCS I and DCS II are remarkably similar. As expected, the mean onset time of AGE is significantly shorter. Ninety-five percent of divers with AGE became symptomatic within 120 minutes, and 95 percent of those with DCS were symptomatic within approximately 33 hours.

The mean onset time of AGE is significantly shorter than that of DCS.

Table 4.5 *Symptom Onset Time after Surfacing (hours): All Divers*

Classification	N	Mean	Standard Deviation	Median	95% Time*
DCS-I	161	9.3	15.8	1.5	48.0
DCS-II	383	6.3	10.5	1.0	28.9
AGE	46	2.4	14.8	0.02	1.6
All DCI	590	6.8	12.7	1.0	33.0

** Time after surfacing by which 95 percent of individuals have developed at least one symptom.*

Table 4.6 *Symptom Onset Time after Surfacing (hours) Divers with Altitude Exposure Excluded*

Classification	N	Mean	Standard Deviation	Median	95% Time*
DCS-I	119	7.4	14.2	1.0	28.8
DCS-II	265	4.6	7.8	1.0	24.0
AGE	29	0.2	0.4	0.02	0.4
All DCI	413	5.1	9.9	1.0	24.0

** Time after surfacing by which 95 percent of individuals have developed at least one symptom.*

16.6 percent of all divers in the 1995 database reported having experienced symptoms prior to their last dive

Since it is established that altitude exposure can precipitate symptoms after a delay, the data have been analyzed after excluding all cases in which altitude exposure occurred. They are displayed in Table 4.6. Inspection of Table 4.6 provides clinically useful information — for instance, one half of cases of DCI have symptom onset within 60 minutes after surfacing. In the absence of any altitude exposure, 95 percent of cases develop symptoms within 24 hours.

Eliminating post-dive altitude exposures essentially eliminates all onset time differences between DCS I and DCS II.

Table 4.7 *Decompression Illness Symptoms Prior to Last Dive*

Sex	1995 Percent	1994 Percent	1993 Percent	90-92 Percent	88-89 Percent
Male	16.1	17.6	17.7	16.9	13.4
Female	18.9	20.4	26.6	36.0	26.0
TOTAL	**16.9**	**18.4**	**20.5**	**22.1**	**16.5**
	n=590	*n=566*	*n=508*	*n=1,361*	*n=649*

Symptoms Prior to Last Dive

One hundred divers — 16.6 percent of all divers, 15.9 percent of males, 18.3 percent of females — reported having experienced symptoms prior to their last dive (Table 4.7, above).

The proportion of divers continuing to dive after symptom onset is similar to that in previous years. This may indicate a lack of awareness of the symptoms of DCI, a tendency to ignore minor symptoms or attribute them to some cause other than DCI, or perhaps the potential for yielding to perceived peer pressure (i.e., not wishing to cut short everyone else's dive). A distribution of symptoms experienced prior to the last dive is shown in Table 4.8.

Table 4.8 *Symptom Classification of Divers Experiencing Symptoms Prior to Last Dive*

Symptom Category	Number	Percent
Severe Neurological	9	9.0
Mild Neurological	42	42.0
Pain/Skin/Nonspecific	44	44.0
Difficulty Breathing	5	5.0
Tinnitus/Hearing Loss	0	0.0
TOTAL	**100**	**100.0**

Nine individuals continued to dive with severe neurological symptoms. One individual had paralysis in both legs but dived again 24 hours later. This person was treated four hours after the final dive but continued to have residual neurological symptoms for three months.

Three individuals had differing degrees of difficulty walking: one was treated five days after the final dive and continued to have pain for two months; another was treated two hours after surfacing, but even after eight treatments experienced residual neurological symptoms for four months; the last diver was treated 12 hours post-dive, and after three treatments was completely relieved of all symptoms. Three individuals continued to dive while having visual disturbances while another had bowel problems.

One individual, after having been unconscious, made one more dive the next day. The person was treated 36 hours after the final dive and received two treatments, the initial one with extensions. The diver continued to have residual neurological symptoms for five months.

Previous Decompression Illness

Table 4.9.1 (page 52) shows the type of previous dive accident reported by injured divers, based on the classical diagnosis. Table 4.9.2 (page 52) shows previous dive accident by the DAN classification of the severity of symptoms. Similar to previous years, both show that, of the 590 divers who provided the relevant information, a total of 64 (10.8 percent) had previously experienced either possible DCS, actual DCS or pulmonary barotrauma. Divers with previous accidents may possibly be ones with more experience and hence at an inherently higher risk because of increased exposure to the environment.

The proportion of divers continuing to dive after symptom onset . . . may indicate a lack of awareness of the symptoms of DCI, a tendency to ignore minor symptoms or attribute them to some cause other than DCI, or yielding to perceived peer pressure.

Table 4.9.1 ***Previous Accident Classification by Present Diagnosis***

	Previous Accident Classification					
Present Diagnosis	**Possible DCS**	**DCS**	**Pulmonary Barotrauma**	**AGE**	**None**	**TOTALS**
DCS-I	6	6	1	0	148	161
DCS-II	20	26	1	2	334	383
AGE	0	2	0	0	44	46
TOTALS	**26**	**34**	**2**	**2**	**526**	**590**

Table 4.9.2 ***Previous Accident Classification by Presenting Symptoms***

	Previous Accident Classification					
Previous Symptoms	**Possible DCS**	**DCS**	**Pulmonary Barotrauma**	**AGE**	**None**	**TOTALS**
Severe Neurological	8	9	0	2	127	146
Mild Neurological	16	15	1	0	308	340
Pain/Skin/ Nonspecific	2	10	1	0	91	104
TOTALS	**26**	**34**	**2**	**2**	**526**	**590**

Divers who reported previous DCS had logged more dives than those who had not reported such history.

Indeed, divers who reported previous DCS (N = 34) had logged more dives (median number 500) than those who had not reported such history (median 50 dives), and nine of these divers reported having logged 1,000 or more dives. Divers with recurrent DCI could also be at higher risk because of high-risk diving patterns. This is not supported by the available data, since only nine of 34 (26.5 percent) of divers with previous DCS had either rapid ascent, buoyancy or equipment problems or were not within table or computer limits — obviously lower than the 39 percent in the entire 1995 accident population. Only two individuals didn't follow a table or use a dive computer on the dive.

The probability of DCI in this recreational population is unknown; also unknown is the frequency of DCI symptoms in divers who did not experience DCI in 1995. Because of these two factors, it is not possible to state whether this apparently high frequency of recurrence implies an intrinsically higher risk for divers who have previously experienced DCI.

Summary

- In one-third of DCI cases, pain was the presenting (initial) symptom, while nearly 60 percent of divers with DCI experienced pain at some point in their illness.

- The second most frequent presenting symptom was numbness (one-fifth of cases), which occurred at some time in over 50 percent of cases.

- One-quarter of all DCI cases had severe neurological symptoms (altered consciousness, paralysis, visual symptoms, bowel/bladder problems, gait abnormalities or convulsions).

- The frequent progression from mild to severe symptoms provides support for the recommendation that all divers with symptoms of DCI should obtain early evaluation and treatment.

- The traditional classification scheme (DCS I, DCS II, AGE) is frequently applied incorrectly. Over 60 percent of 161 divers classified as DCS I reported neurological symptoms to DAN.

- In one-half of the cases reported, the first symptoms developed within one hour of surfacing. In 95 percent of these cases, DCI symptoms developed within 33 hours, and in the absence of altitude exposure, 95 percent were symptomatic within 24 hours.

- Seventeen percent of divers with DCI divers reported having experienced symptoms before their last dive; nine reported severe neurological symptoms, supporting the need for more education regarding the symptoms of DCI.

- Previous decompression illness was reported by 10 percent of divers in this database. These divers tended to be more experienced, and compared to the others in the database, these divers had fewer reported rapid ascents, buoyancy problems, equipment problems and depth-time exposures outside table or computer limits.

The frequent progression from mild to severe symptoms of DCI provides support for the recommendation that all divers with symptoms of DCI should obtain early evaluation and treatment.

Treatment

The ultimate outcome for divers experiencing decompression illness depends on early recognition of symptoms, prompt diagnosis with early institution of appropriate first aid and definitive treatment. The following data summarize the treatment information submitted to DAN in 1995 for the 590 reported cases of decompression illness.

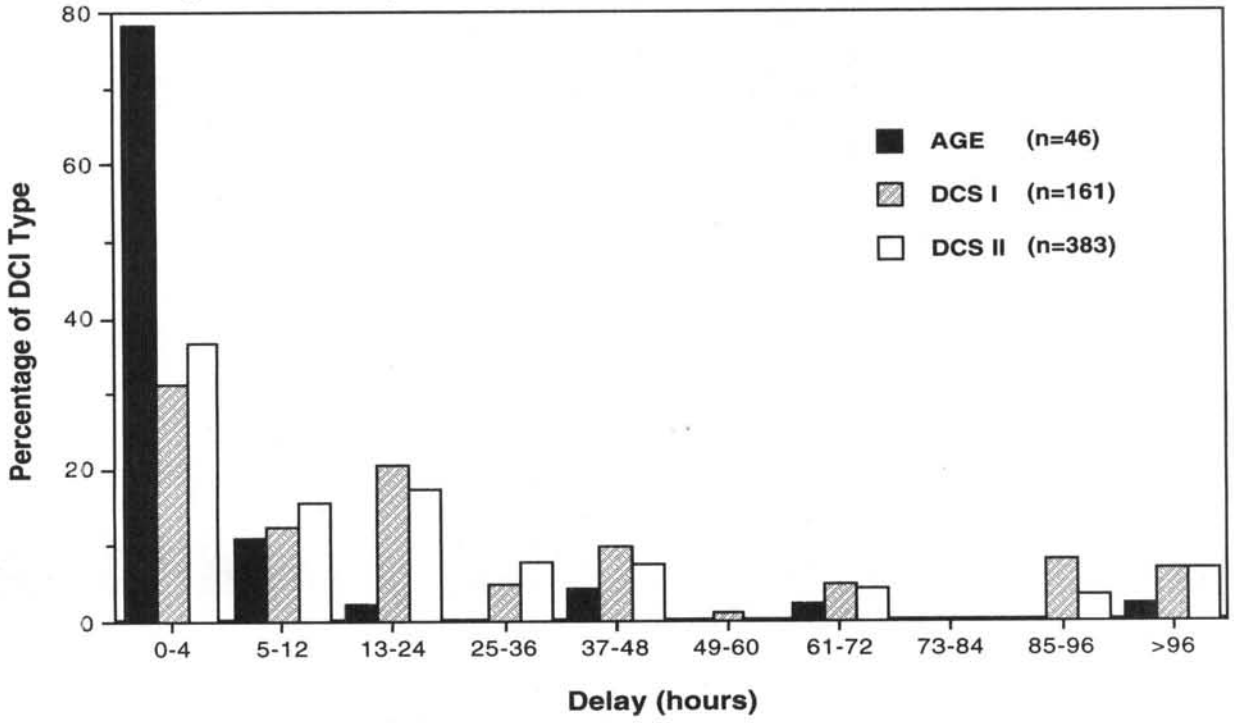
A large percentage of divers with symptoms of AGE seek assistance within the first four hours of symptom onset, while only 35 percent of all DCS cases did.

Delaying the Call for Assistance

The data presented in Graph 5.1 are similar to that of previous years and show that a large percentage of divers with symptoms of AGE seek assistance within the first four hours of symptom onset. In 1995 this number reached nearly 80 percent, an increase of 15 percent over the previous year. This may not only reflect the emergent nature and severity of the symptoms of AGE, but is likely also related to better diver education.

Only 35 percent of all DCS cases reporting to DAN in 1995 did so in the first four hours of symptom onset (DCS I n=50; DCS II n=141, out of 544 total DCS cases). As in past years, the data indicate considerable delay and variability in time from recognized symptom onset to the time of request for medical advice. Of continued concern is the nearly 7 percent of DCI cases that waited more than 96 hours prior to seeking assistance. Although this could be in part related to symptom denial, it also could be partially due to poor recognition of symptoms and inadequate diagnosis.

Graph 5.1 *Delay From Symptoms Onset to Calling for Assistance*



Thirty-eight percent of all DCI cases in the 1995 database initially contacted DAN — either through the Diving Emergency Hotline or through the Medical Information Line (Graph 5.2, below). An additional 31 percent of all cases first contacted a local physician, hospital, emergency department or recompression facility for assistance and/or evaluation. Eight percent of all reported cases received initial assistance from the U.S. Coast Guard or emergency medical services (EMS), while the remaining 3 percent utilized the services of airport and hotel personnel, insurance companies, friends and the U.S. military. Twenty-one percent of reported DCI cases initially sought advice from their dive instructors or dive guides, an increase of 7 percent over the previous year. This underscores the importance of the need for dive instructors to be educated and trained in the recognition of the symptoms of DCI and to be well-informed in implementing proper procedures for first aid measures. These procedures include contacting DAN for referral to closest appropriate physician and/or recompression facility.

Thirty-eight percent of all DCI cases in the 1995 database initially contacted DAN.

Graph 5.2 ***First Contact for Assistance***

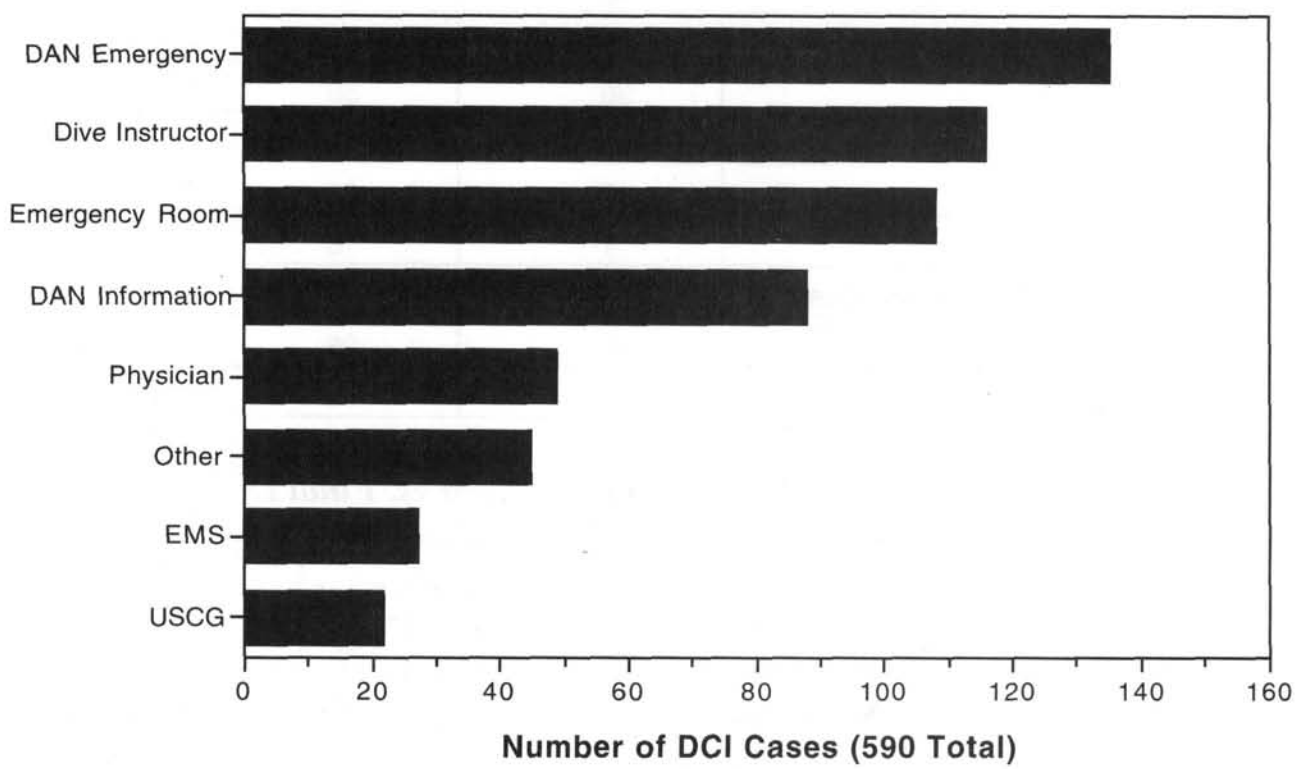


Table 5.1.1 (page 56) shows the delay in hours from time of the initial call to time of recompression therapy as a function of who was called. The shortest delays are reported for EMS, U.S. Coast Guard, instructors and direct contact with a hyperbaric facility (two, seven, six and seven hours respectively). This reflects the more emergent nature of most of these calls to these facilities, as shown in Table 5.1.2. More than 93 percent of initial calls to the EMS or

Many DCI cases contact DAN following an initial call to other sources, such as the EMS.

Coast Guard are either DCS II or AGE ,whereas only 63 percent of calls to DAN were of a more serious nature. Data collected from the DAN on-call medics and physicians indicates that many of these cases contact DAN following an initial call to other sources (333 of 1,899 calls were referred for further evaluation). Calls to the DAN Diving Emergency Hotline resulted in about the same delay as those initially contacting an emergency room. Those persons waiting 30 hours or longer to report symptoms were most likely non-emergent, so a longer delay to treatment will be expected since there would be time for a more complete medical workup. Also, DAN handles many calls from remote areas where there may be inconceivable delays in evacuating the injured diver to a recompression facility.

Table 5.1.1 ***Delay From Initial Call to Recompression Therapy***

Contact	Time to Initial Call (mean hours)	Time to Rx Therapy (mean hours)	Difference in Time (hours)
MD	48	80	32
DAN Nonemergency	69	91	22
Other	36	50	14
DAN Emergency	32	43	11
ER	21	30	11
USCG	1	8	7
Recompression Facility	22	29	7
Instructor	20	26	6
EMS	13	15	2

Table 5.1.2 ***Initial Contact Called vs. Final Diagnosis***

Contact	DCS I	DCS II	AGE	Total	% of Serious Cases (II & AGE)
MD	12	35	6	53	77.0
DAN Nonemergency	31	56	1	88	65.0
Other	3	11	1	15	80.0
DAN Emergency	49	84	2	131	63.0
ER	29	74	5	108	73.0
USCG	1	15	6	22	95.0
Recompression Facility	4	16	2	22	82.0
Instructor	30	75	15	120	75.0
EMS	2	17	8	27	93.0

Initial Contacts to DAN

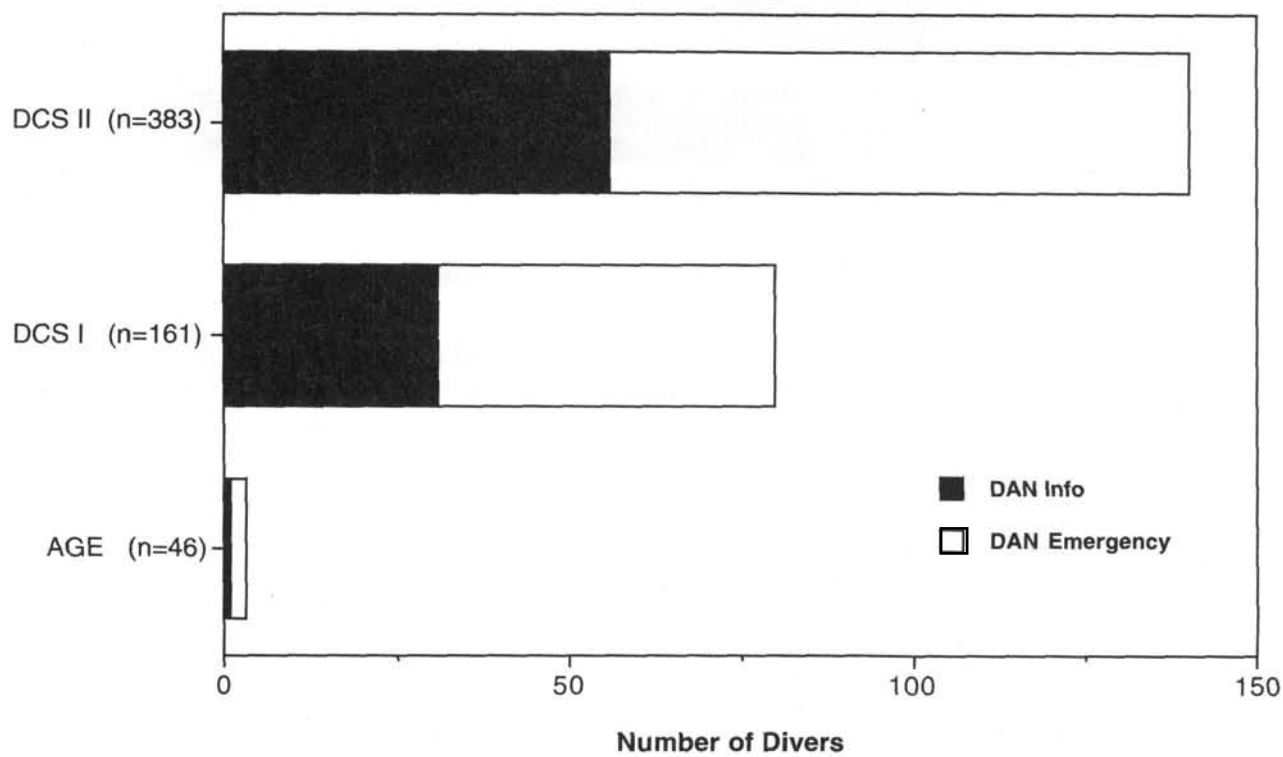
Of the 223 divers who utilized DAN as the initial contact, 220 did so for assistance with either DCS I (n=80) or DCS II (n=140). Graph 5.3 (below) shows the breakdown of these contacts, indicating whether they utilized the emergency or nonemergency telephone lines. The percentage of divers in 1995 who utilized the nonemergency information line for consultation on DCS II increased from 30 percent to 40 percent (n=56 out of 140 DCS II cases) when compared to 1994 data. Sixty-five percent of all cases of DCS II and AGE initially came over the Medical Information Line. This continues to be a disturbing statistic given the importance of prompt recognition and treatment of cases of severe neurological DCS.

Only three of the 46 (6.5 percent) reported AGE cases in 1995 utilized DAN as the initial point of contact for assistance. Two of these three were reported through the Diving Emergency Hotline. These data are not surprising given the emergent nature and severity of AGE.

Very serious cases seem to easily recognized, with prompt contact of the EMS. Callers to DAN were probably those who were more likely to have denied their symptoms or who were unsure if their symptoms were DCS-related.

Twenty-one percent of reported DCI cases initially sought advice from their dive instructors or dive guides, an increase of 7 percent over the previous year.

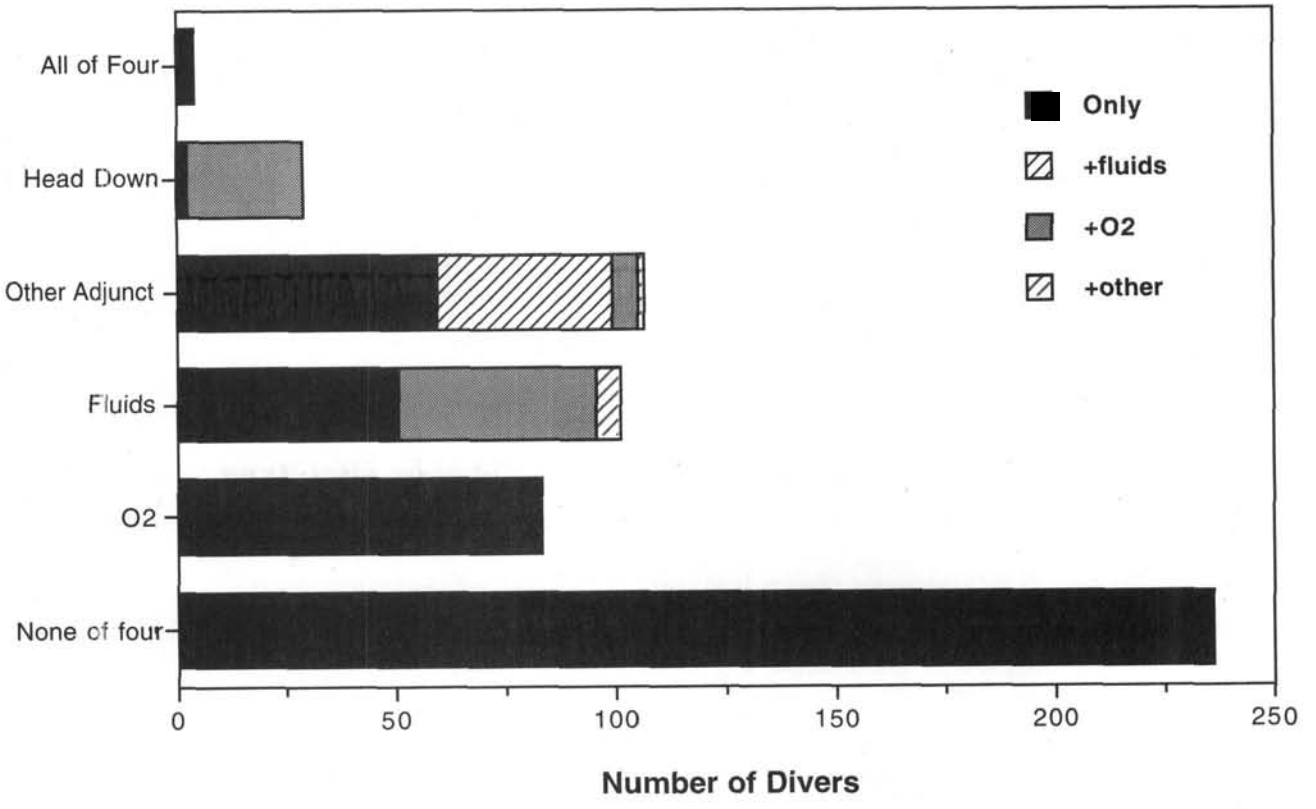
Graph 5.3 ***Intial Call to DAN by DCI Type***



The Use of Oxygen in First Aid

A total of 354 (60 percent) of all DCI cases reported to DAN in 1995 utilized some method of first aid (oxygen, oral fluids, head-down position or aspirin). Of the 590 DCI cases, 190 (32 percent) utilized oxygen alone or in combination with other treatment modalities for first aid (Graph 5.4, page 58). Eighty-three cases (14 percent) utilized oxygen only, while 45 (8 percent) used fluid and oxygen therapy.

Graph 5.4 ***First Aid Used***



The reported increase in supplemental oxygen use (with or without other therapy) — from 26 percent to 33 percent between 1993 and 1994 — unfortunately remains stable for 1995.

Fifty cases (9 percent) used fluid alone, while 98 (16 percent) used fluids in combination with other interventions (not including oxygen) as a first aid measure. Ten percent (n=59) used aspirin alone, and 115 (20 percent) used aspirin in combination with some other therapy. There were 236 cases (40 percent), out of all reported DCI cases, in which none of the four treatments were used.

The reported increase in supplemental oxygen use (with or without other therapy) — from 26 percent to 33 percent between 1993 and 1994 — unfortunately remains stable this reporting year. Supplemental oxygen use remains at 32 percent for the 1995 data (83 instances of use out of 590 cases).

Despite much clinical and theoretical evidence that supports the use of supplemental oxygen for the treatment of DCI, in addition to the increase in DAN Oxygen Providers from 8,325 to 9,419 from 1994 to 1995, this number remains disappointingly low.

Table 5.2 *Field and Hospital Oxygen: 1993-1995*

Diagnosis	1993 (n=508)			1994 (n=566)			1995 (n=590)		
	Total #	O2 Use	%	Total #	O2 Use	%	Total #	O2 Use	%
AGE	49	41	83.7	55	44	80.0	46	38	82.6
DCS-I	117	69	59.0	144	79	54.9	161	67	41.6
DCS-II Severe	98	70	71.4	153	64	41.8	118	81	68.6
DCS-II Mild	244	148	60.7	214	153	71.5	265	141	53.2
TOTALS	**508**	**328**	**64.6**	**566**	**340**	**60.1**	**590**	**327**	**55.4**

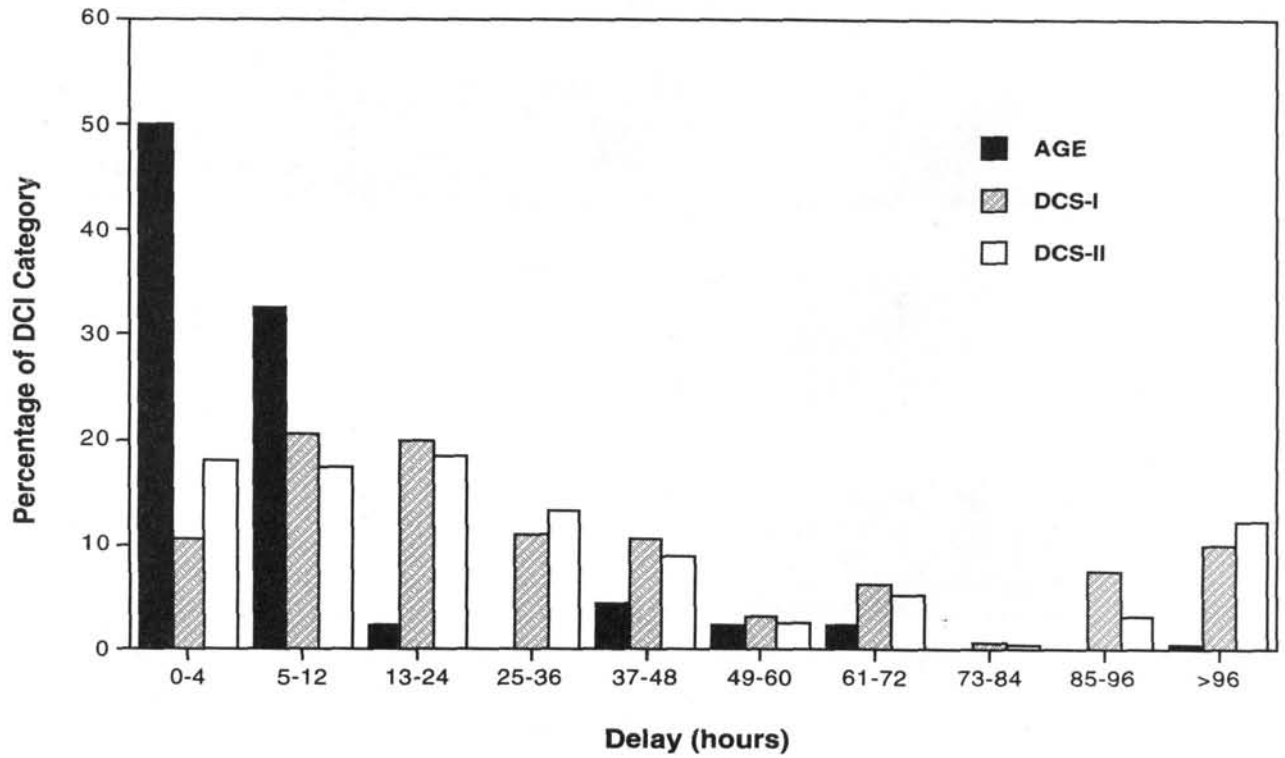
The distribution of surface oxygen use is listed in Table 5.2 (page 55). The efficacy of surface oxygen use in conjunction with hyperbaric recompression therapy is discussed later and shown in Graphs 5.7 and 5.8 (pages 61-62). Unfortunately, DAN does not have data on the duration of oxygen breathing or the type of delivery system used, both important factors in treating DCI.

Delay to Recompression

Although significant variability from the time of symptom onset to beginning of recompression therapy continues, (see Graph 5.5 below), there is an improvement in reduction in delay time for cases

With surface oxygen, there is an improvement in reduction in delay time to recompresion compared to cases of AGE.

Graph 5.5 *Delay from Symptom Onset to Recompression Therapy*



1995 data show a reduction in delay time to hyperbaric therapy for AGE cases.

of AGE. Twenty-three of the 46 cases of AGE (50 percent) received hyperbaric therapy within four hours of symptom onset, while 83 percent (n=38) were recompressed within 12 hours. This is a reduction in delay time, compared to an increase from 1994 (37 percent and 67 percent) respectively, and is likely related to better diver education in symptom recognition and emergency management, together with improved emergency evacuation procedures.

The delay to treatment for cases of DCS I and DCS II was similar to previous years' reports, with 11 percent and 18 percent respectively (16 of 161 DCS-I, and 69 of 383 DCS-II), being treated within four hours of symptom onset; and 31 percent and 36 percent (50 of 161 and 136 of 383 DCS-II) being treated within 12 hours.

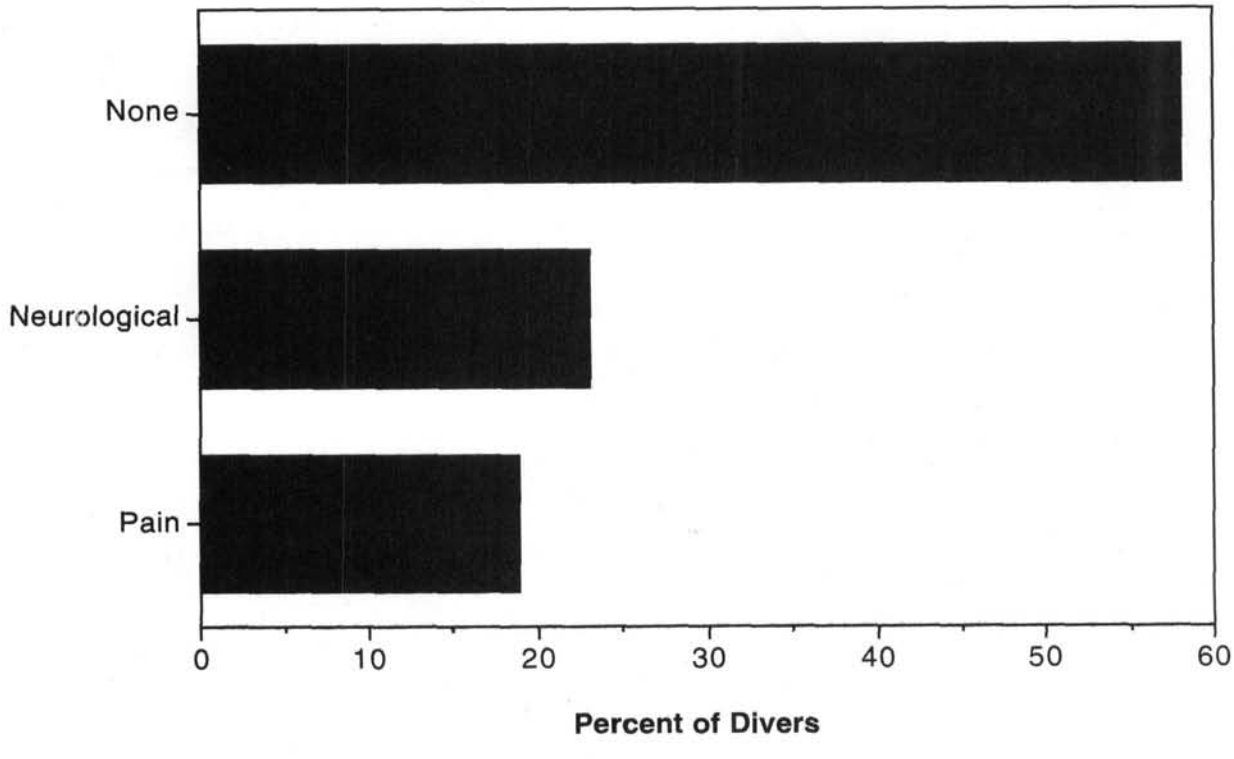
The causes for delay to treatment can include a variety of reasons and include:

- denial of symptoms by the injured diver;
- failure to recognize that signs and symptoms were due to DCI;
- remote dive locations requiring long intervals until evacuation; and
- waiting to see if symptoms spontaneously resolve.

Effectiveness of Emergency Hyperbaric Oxygen Therapy

Graph 5.6 (below) shows that hyperbaric oxygen therapy for the 1995 DCI cases reported to DAN resulted in complete resolution of symptoms at the end of all hyperbaric therapy slightly more than half of the time (58 percent, 343 of 590 cases).

Graph 5.6 ***Post-Treatment Residuals***



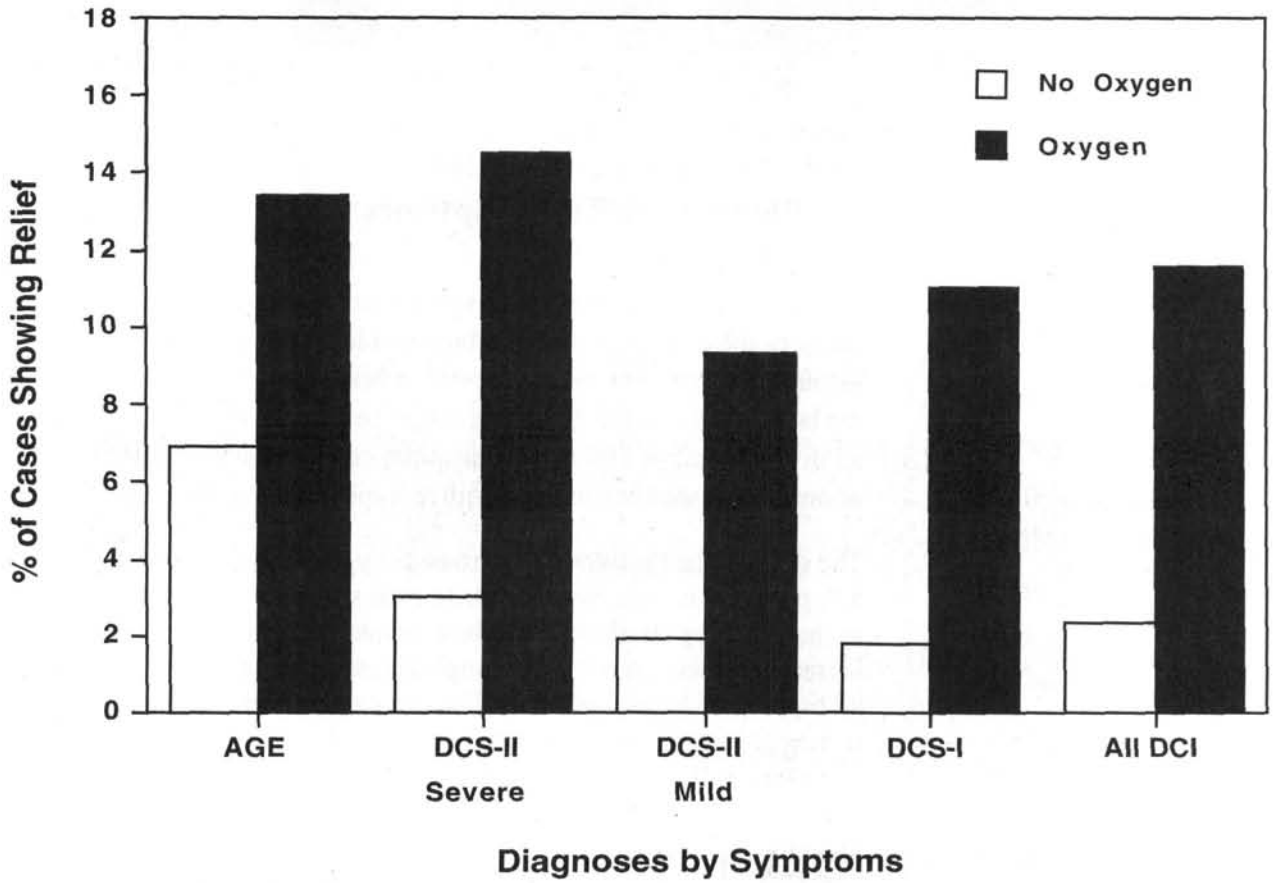
Of the divers with residuals, 23 percent had residual neurological symptoms, while 19 percent had pain-only residuals (136 and 111 of 590 cases). These data are consistent with those reported in past years.

Graphs 5.7 and 5.8 (pages 61-62) show the improvement in overall symptom-free outcome for those divers who receive emergency first aid surface oxygen.

Twelve percent of the reported DCI cases in 1995 were symptom-free following surface oxygen before recompression therapy, whereas only 2 percent were symptom-free without oxygen before recompression. Fifty-eight percent of all DCI cases were symptom-free following recompression therapy when the divers were given oxygen first aid, whereas only 55 percent of the recompressed divers not treated with emergency oxygen were symptom-free. All cases reported were eventually treated, even if they were experiencing pre-treatment relief.

Fifty-eight percent of all DCI cases were symptom-free following recompression therapy when the divers were given oxygen first aid.

Graph 5.7 ***Relief of Symptoms Before Recompression***

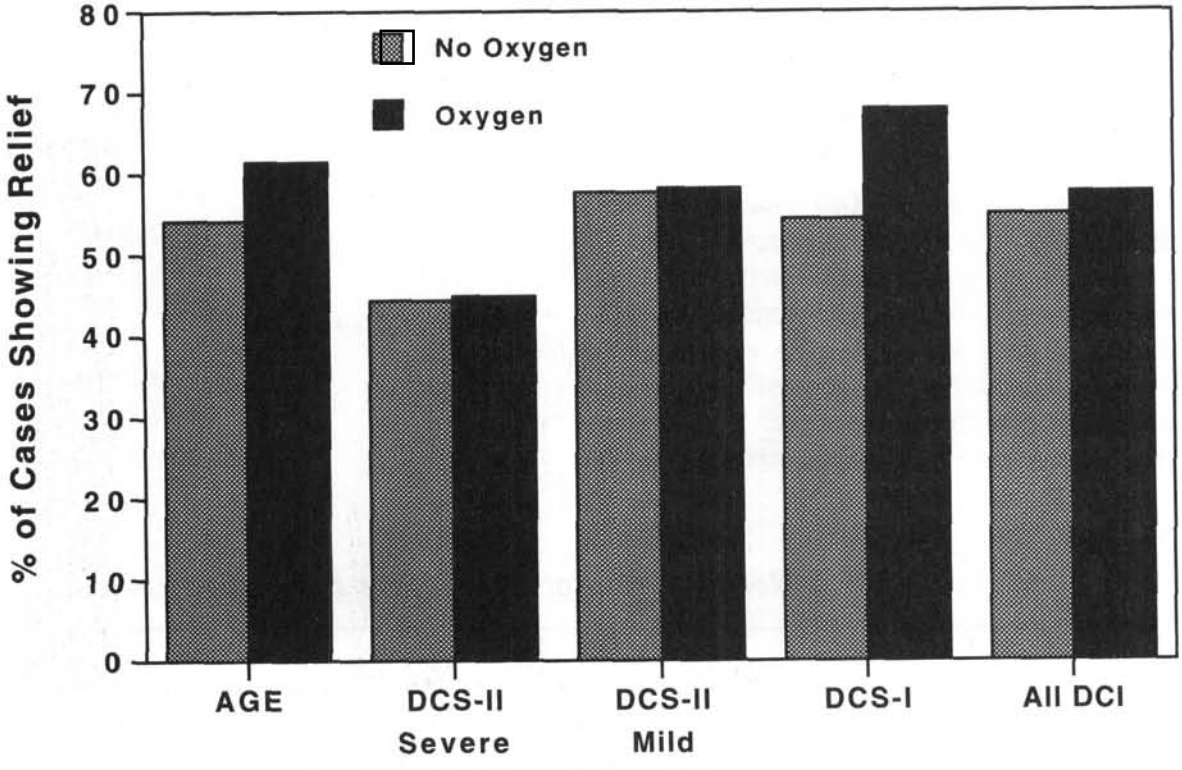


DEFINITIONS

DCS II Severe — includes neurological symptoms including unconsciousness, semi-consciousness, paralysis, speech and visual disturbances, difficulty walking, bowel and bladder problems, and convulsions.

DCS II Mild — includes all other neurological symptoms (refer to Table 4.1, page 46) for a list of all symptoms.

Graph 5.8 ***Relief of Symptoms After Recompression***



Increasing delays in hyperbaric oxygen therapy result in incomplete resolution of symptoms for all types and severity of DCI.

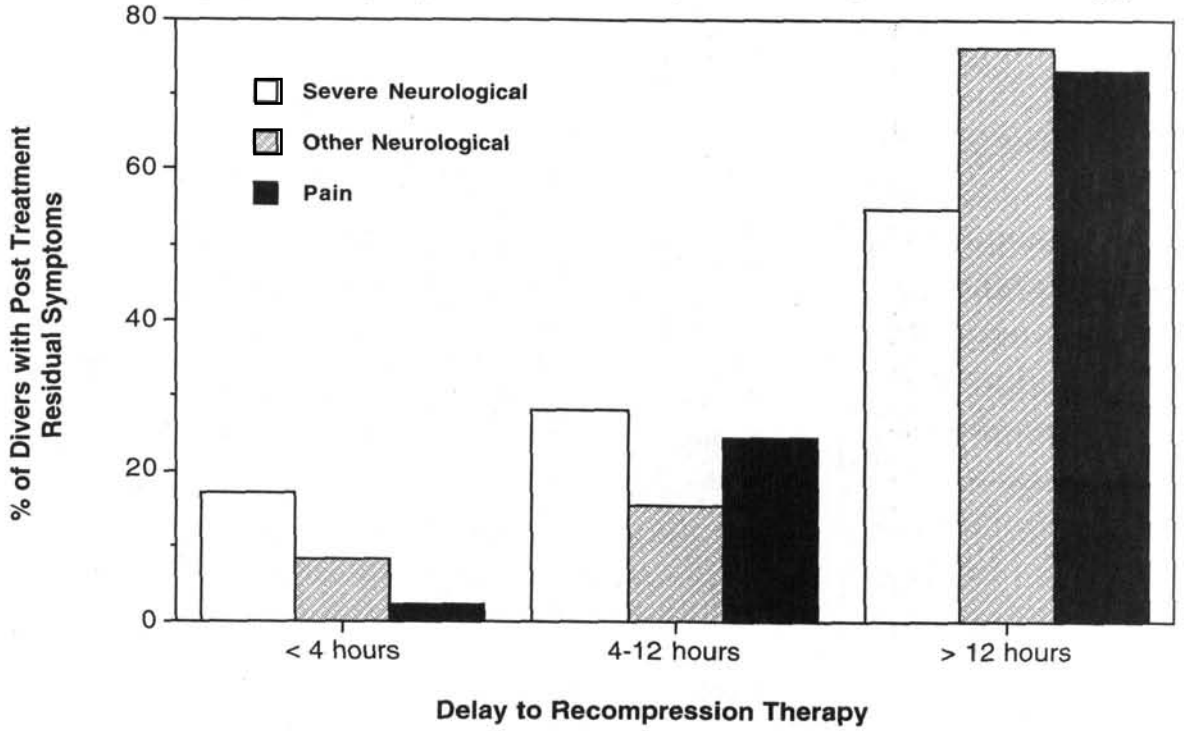
While the benefits of breathing surface oxygen appear impressive, many of these divers may have breathed less than 100 percent inspired oxygen concentrate for only a brief period. Therefore, the benefits of oxygen breathing might be even more apparent if all divers breathed 100 percent inspired concentrate from the time of onset of symptoms until definitive hyperbaric treatment.

The delay to institution of hyperbaric oxygen therapy (see Graph 5.9, page 63) is directly correlated to the success of the treatment as measured by its ability to reduce or totally resolve the symptoms. Increasing delays result in incomplete resolution of symptoms for all types and severity of DCI. The percent of divers with post-recompression residual symptoms continues to decrease, likely due in part to early symptom recognition and emergency first aid.

Summary

■ Symptom recognition and emergency first aid of suspected DCI is important in the ultimate resolution of decompression problems. Delays due to confusing symptoms, symptom denial by the diver and remote dive locations far removed from treatment facilities all contribute to the presence of residual symptoms after recompression

Graph 5.9 ***Percent Divers with Post-Recompression Residual Symptoms as a Function of Percentage of Divers with Pre-Recompression Symptoms and Delay to Recompression Therapy***



therapy. The greater recognition of symptoms of AGE, perhaps due to their severity and acute nature, results in more prompt treatment. As an industry, we must work hard to educate divers and instructors in the recognition of symptoms of DCS.

■ The number of divers who recognize the symptoms of DCI and begin immediate therapy with surface-supplied oxygen continues to increase each year, with improvements in the overall success of treatment. The rising percentage of divers initially contacting dive instructors supports the need for increased education and awareness by this group.

■ One-third of all DCI cases reported to DAN in 1995 involved the use of supplemental oxygen. This continues to be an unfortunately low percentage of DCI cases reported to DAN, especially given the proven efficacy of surface-supplied oxygen. As also noted in last year's report on 1994 data, an increasing number of divers terminate the use of surface oxygen without receiving medical evaluation. In many instances these same divers report to a hyperbaric facility at a later time and are found to have significant deficits on exam.

■ Delay to recompression therapy is associated with a significantly greater probability of residual symptoms for all types of DCI.

The number of divers who recognize the symptoms of DCI and begin immediate therapy with surface-supplied oxygen continues to increase each year.

Scuba Fatalities

Over the past 25 years, 2,786 recreational scuba deaths have been reported among residents of the United States. The average number of deaths for these years has been 111 deaths per year.

Introduction

Divers Alert Network began collecting information on recreational scuba fatalities in 1989. Data shown for years prior to 1989 were collected by the National Underwater Accident Data Center (NUADC) at the University of Rhode Island. Over the past 25 years, 2,786 recreational scuba deaths have been reported among residents of the United States. The average number of deaths for these years has been 111 deaths per year. The average number of deaths during the last 10 years has been 98 deaths per year. Including deaths which occurred in 1995 (104), two of the past 10 years has had over 100 fatalities reported. Of the last five years, four had over 90 scuba deaths, and one had over 100.

The 1995 report on scuba fatalities is based on data from 104 scuba fatalities, which occurred between Jan. 1-Dec. 31, 1995. Only deaths involving U.S. citizens are included.

Exclusion Criteria

Several factors are used to exclude a case from being followed up and entered into the fatality database. The fatality may have involved:

- a commercial, scientific or occupational diver;
- a free-diver or snorkeler
- a foreign diver in foreign waters
- a nondiving related accident, such as a boating accident.

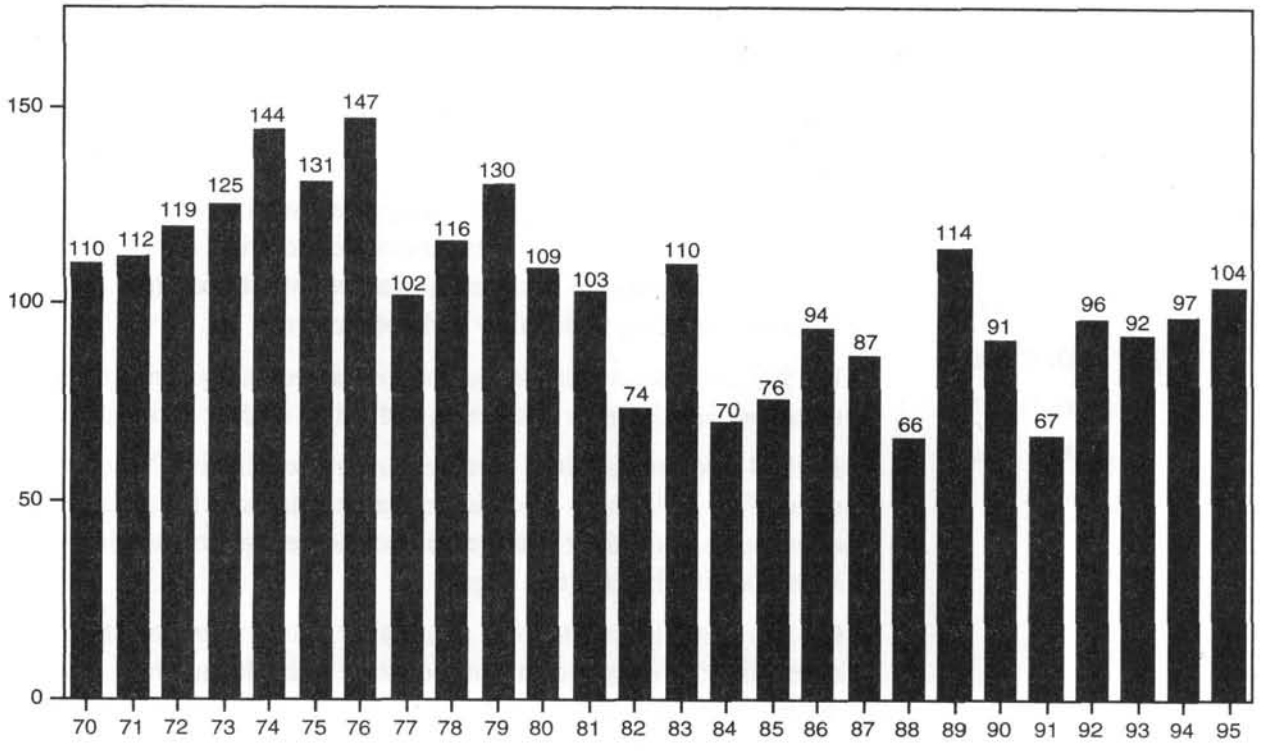
The DAN fatality database does not include any of these categories.

1995 DAN Fatality Data: What Is Included

In 1995, DAN received notice of 161 possible scuba deaths. DAN collects information on all reported fatalities to determine the activity that was occurring at the time of death. The DAN medical staff collects information only pertaining to recreational, personal-task and technical scuba diving fatalities involving U.S. citizens worldwide and foreign divers in U.S. waters.

DAN excludes cases which involve any of the above mentioned exclusion criteria. Of the 161 deaths reported in 1995, eight were commercial divers, 24 were free-divers, 18 were foreign nationals, and seven were non-diving-related.

Graph 6.1 *Yearly U.S. Recreational Diving Fatalities*



Breakdown of Fatalities: Year, Certification, Type of Dive

Graph 6.2 (page 66) gives a breakdown of recreational scuba deaths, which is made on the basis of information available on each case. Deaths among certified divers who reportedly dived within the limits of their certification and experience accounted for 79 deaths in 1995. This is slightly higher than the 73 in 1994.

The number of recreational divers who were attempting to make a dive they were not qualified for has averaged 10 deaths per year. Based on information on certification level and advanced training contained in fatality reports received at DAN, these individuals were performing dives, such as technical-level diving that requires special training and equipment that they did not possess (a technical dive is defined below). The largest number of these deaths involved attempts at deep diving, wreck penetration or cave diving. In 1995, this number represented 15 fatalities, as it did in 1994.

In this report, a technical dive is defined as one in which one of the following conditions existed:

- Diving to more than 130 feet/40 meters;
- Using breathing mixture other than compressed air; or
- Decompression or overhead diving (diving in shipwrecks or caves).

These levels of exposure go beyond established recreational limits. Not all divers who make technical dives have the specialized training for the activity.

The largest number of deaths involving divers who were unqualified for the dive they were making include attempts at deep diving, wreck penetration or cave diving.

Deaths among divers who have received specialized training have never accounted for more than 11 deaths in any given year.

A brief analysis of mixed-gas diving accidents is included in Appendix E. Deaths among divers who have received specialized training have never accounted for more than 11 deaths in any given year. This group averages five deaths per year, with a range of two to 11 deaths annually. In 1995, technical divers accounted for four fatalities.

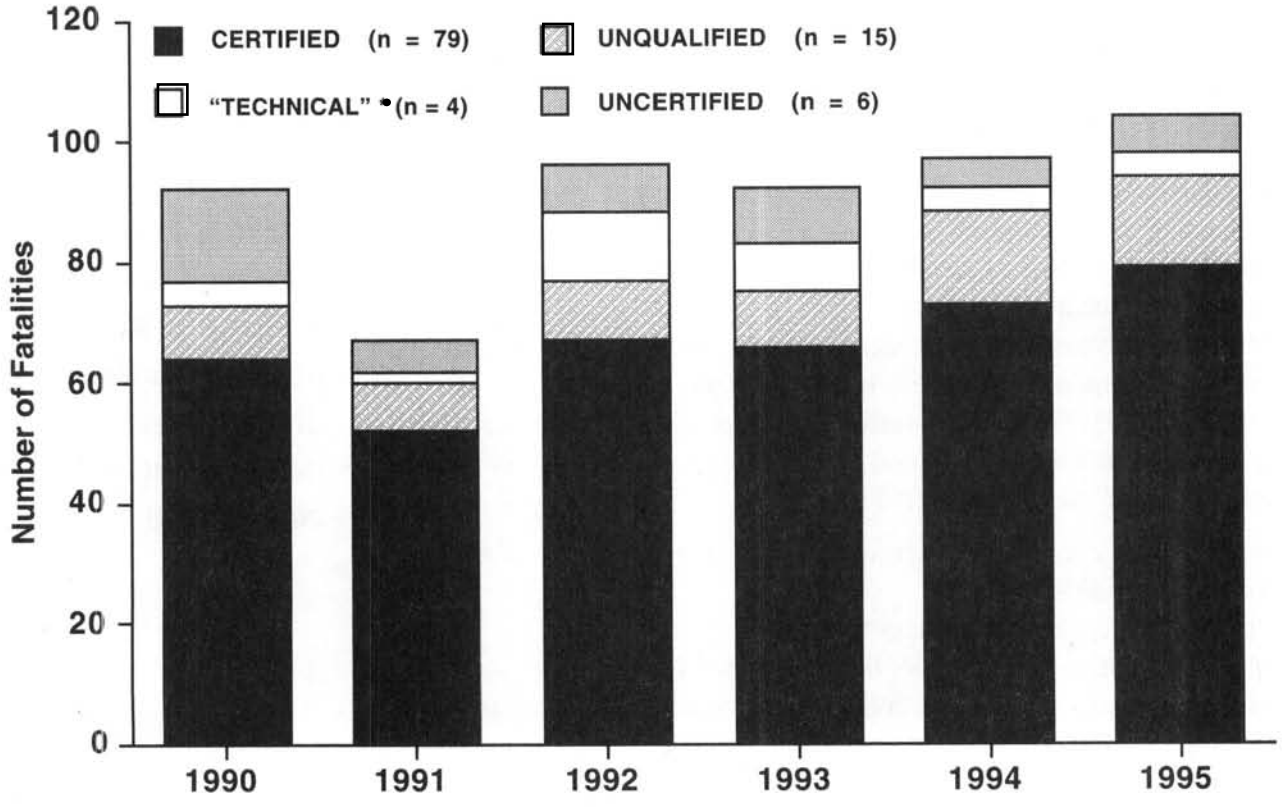
Despite the lack of appropriate training, between five and 15 unqualified divers die each year attempting to scuba dive. Unqualified divers are those making a dive which required additional training which they had not received.

In 1995, student fatalities accounted for six deaths. Students represent those individuals under instruction at the time of their accident.

In 1994, six dive fatalities involved uncertified divers. These were uncertified individuals who did not participate in an instructional dive course. (All diver fatalities are considered in the analysis of scuba fatality data for this Report.)

It is not possible to determine a mortality rate among recreational scuba divers with any degree of certainty since the number of active divers and number of dives in any given year is unknown.

Graph 6.2 *Breakdown of Scuba Fatalities*



* Divers participating in a technical dive who were determined to have had appropriate advanced training

Preliminary Report on 1996 Recreational Fatalities

As of Oct. 1, 1996, 70 fatalities has been reported to DAN for 1996. Of these 70 cases, 18 were certified recreational divers, two were recreational/technical (unqualified divers, based on reports received at DAN), two were technical, and one was conducting a personal task. There was also one known uncertified diver. These are preliminary numbers, and there are likely to be more by the end of 1996 fatalities. Of the 70 fatalities reported thus far in 1996, eight (11.4 percent) have involved women.

As of Oct. 1, 1996, 70 fatalities have been reported to DAN for 1996.

Over half of all fatalities (36 - 51.4 percent) in 1996 occurred between June and September: June (11), July (12), August (6). The number of fatalities in July (12) of 1996 is drastically less than July 1995 (29). Twenty-nine deaths in a single month is the most recorded since DAN started collection in 1989. The summer months (May-September) usually ranges from four to 14 deaths per month.

Florida again has the highest number of reported deaths thus far in 1996. With 16 reported as of this writing, this is less than the 19 deaths confirmed at this time in 1995. Hawaii claimed the second highest number of fatalities, with seven deaths for 1996. In 1995, Hawaii reported only three deaths for the whole year.

California was second highest in diving deaths in 1994, but dropped to third in 1995, with six diving-related deaths. Washington ranked fourth, with three deaths.

It should be noted that Florida, Hawaii and California are the most popular diving destinations in the United States.

Methods of Fatality Data Collection

In 1995, about 30 percent of fatality contacts came to DAN via telephone calls through the DAN network.

In general, case collection evolves from a single telephone call or newspaper clipping to a case series, in which the characteristics of individuals who share a common outcome are described. Unfortunately, in this series the outcome is death, and all the victims died while scuba diving or shortly after diving. Obviously, since death is not the expected outcome of a scuba dive, the detailed study of the cases reported should give us some insight into the causes of these fatalities. In addition, it helps to identify the risks for this group, which are different than the risks for the millions of individuals who dive without a serious problem.

How Information Is Collected — Initial Contacts

Table 7.1 (below) shows the agencies and services that supply DAN with initial information regarding scuba diving fatalities. The majority of reports come from DAN subscription services, which include news clipping services (i.e., Lucè and Burrelle) and computer services (i.e., CompuServe). In 1995, about 30 percent of fatality contacts came to DAN via telephone calls through the DAN network. The DAN network includes calls on the DAN Medical Information Line, the Diving Emergency Hotline and hyperbaric chamber personnel. Medical examiners, coroners, or investigative agencies may also call. Dive agencies also inform DAN of fatalities involving their certified divers.

Table 7.1 *Initial Contacts*

	Inside United States	Outside United States	Total	Percent
Subscription Services	33	6	39	37.5
DAN Network	31	3	34	32.7
Family/Friend	5	5	10	9.6
Lifeguard/Chamber	6	1	7	6.7
Newspaper Direct	3	0	3	2.9
Medical Examiner/Coroner	1	2	3	2.9
Investigative*	3	0	3	2.9
Dive Agency/Shop	2	0	2	1.9
Non Member	1	1	2	1.9
News Station	1	0	1	1.0
Total	**86**	**18**	**104**	**100.0**

* *Police, Sheriff, Marine Patrol and USCG*

The investigative agencies (sheriff and police departments, U.S. Coast Guard, and other reporting agencies) and the medical examiners/coroners who provide fatality incidents to DAN receive bimonthly mailings of *Alert Diver* as well as a complimentary copy of this report.

Since scuba fatalities are relatively rare, many agencies who follow up on fatality investigations are unfamiliar with scuba diving. DAN offers investigators and medical examiners information regarding protocols in investigation and autopsy. In this manner, DAN assists investigation agencies but is not an investigative agency itself.

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

Table 7.2 ***Primary Sources of Information***

Primary Source	Total	Percent
Autopsy and Investigative Report	47	45.2
Investigative Report Only	28	26.8
Medical Examiner Only	11	10.6
Local Contact Only	8	7.7
Family/Friend Only	4	3.8
Medical Examiner and Family/Friend	2	1.9
Medical Examiner, Investigative Report and Family/Friend	1	1.0
Local Contact and Family/Friend	1	1.0
Investigative Report and Local Contact	1	1.0
Newspaper	1	1.0
TOTAL	**104**	**100.0**

Collecting Information After Initial Contact

Table 7.2 (above) shows the primary sources of information used in the analysis of scuba fatalities. DAN usually receives a newspaper clipping, electronic message or a telephone call. These can be used as a starting point for the collection of more information.

DAN will verify a reported fatality through local authorities; once this has happened, information-gathering can begin. DAN obtains information on fatalities from autopsy or coroner reports and investigative agency reports (i.e., sheriff, police, USCG, Marine Patrol, lifeguard services or coroner/medical examiner reports). In 1995, in almost 50 percent of all cases, DAN received an autopsy or coroner's report and an investigative report. If possible, DAN receives statements from persons involved with or witnesses to the dive event. This may include dive buddies, other divers or rescue diver personnel. In some cases, DAN may speak with the decedent's family to receive information regarding the deceased's medical history and dive experience level prior to the fatality.

There has been an overall decrease in the average number of deaths in Florida and California since the early 1980s.

Diving fatalities fall under the jurisdiction of the local medical examiner, and the decedent is frequently subjected to a forensic autopsy. DAN may obtain autopsy reports on many of these cases. In 1995, a body was recovered in 95 incidents, and autopsies were performed on 79 of these cases; 12 decedents did not have an autopsy performed, and four cases did not have enough information to determine if an autopsy was performed. Some states do not request an autopsy on an accidental death, or the medical examiner decided one was unnecessary. An autopsy report was available to DAN in 60 out of the 79 cases — which represents 75.9 percent of all autopsied cases.

In general, DAN is receiving more autopsy and investigative reports for analysis because of increased efforts by the DAN medical staff in collecting this information and because of the increased cooperation of many investigative agencies and medical examiner offices. Often sufficient information is available to review dive fatalities, but an autopsy report makes it possible for DAN's medical personnel to define contributing medical conditions and individual behaviors which may contribute to scuba fatalities.

Unfortunately, all cases have some information missing due to the nature of our non-investigative data collection — most notably, the previous health record. This is rarely obtained, except at autopsy. Information can also be limited because of local or state regulations, litigation, family request or the remoteness of foreign locations. All cases are counted, however, unless they fall into one of the previously mentioned exclusion categories.

Locations of Scuba Fatalities

Tables 7.3 and 7.4 (pages 71-72) show the location of scuba fatalities by state within the United States or by foreign locations, though no conclusion can be drawn concerning the relative safety or risk of any of the dive locations listed. Typically, deaths occur at a variety of dive sites and under various conditions. The number of deaths in Florida and California represent over 30 percent of all deaths in the United States, but these deaths occurred at many different dive sites throughout the state.

As with accident cases, both Florida and California have a large population of certified divers and are probably the most frequented U.S. diving states. The combined number of fatalities in Florida and California remained the same from 1994 to 1995 (36), but in 1995 Florida had two less deaths; California had three more.

There were four deaths in the combined geographic area of New York and New Jersey in 1995. From 1989 to 1994 there were 36 deaths in this region, with a range of two to six deaths per year.

Table 7.3 *Location of Diving Fatalities by State*

	Certified	Uncertified	Unknown	Total	Percent
Florida	18	4	0	22	21.2
California	12	1	1	14	13.4
Washington	10	0	0	10	9.6
Massachusetts	4	0	1	5	4.8
Arkansas	4	0	0	4	3.8
Hawaii	2	0	1	3	2.9
Connecticut	2	0	0	2	1.9
Louisiana	2	0	0	2	1.9
Michigan	2	0	0	2	1.9
New Jersey	2	0	0	2	1.9
New York	1	0	1	2	1.9
North Carolina	2	0	0	2	1.9
Pennsylvania	2	0	0	2	1.9
Rhode Island	2	0	0	2	1.9
Texas	2	0	0	2	1.9
Wisconsin	2	0	0	2	1.9
Illinois	1	0	0	1	1.0
Indiana	1	0	0	1	1.0
Minnesota	1	0	0	1	1.0
New Mexico	1	0	0	1	1.0
Nevada	1	0	0	1	1.0
Tennessee	1	0	0	1	1.0
Utah	1	0	0	1	1.0
West Virginia	1	0	0	1	1.0
Total	**77**	**5**	**4**	**86**	**82.6**

In 1995, the five deaths in this region did not involve divers who were believed to be technical divers, based on the information received at DAN. In fact, one of the fatalities involved a student in an open-water course, another involved a diver struck by a jet ski, and two involved certified divers. In 1995, five deaths occurred in Massachusetts. This is similar to the four deaths in 1994. The 1992 numbers were high because there were five technical divers involved in deep, advanced dives.

Table 7.4 *Location of Diving Fatalities Outside the United States*

Country	Certified	Uncertified	Unknown	Total	Percent
Bahamas	6	0	0	6	5.8
Mexico	4	0	1	5	4.8
Guam	1	1	0	2	1.9
Antilles	1	0	0	1	1.0
Cayman Islands	0	0	1	1	1.0
Fiji	1	0	0	1	1.0
St. Martin	1	0	0	1	1.0
U.S. Virgin Islands	0	0	1	1	1.0
Total	**14**	**1**	**3**	**18**	**17.4**

Based on reports to DAN, the number of U.S. citizens who died while scuba diving abroad represented 17.4 percent of all fatalities recorded in 1995

Based on reports to DAN, the number of U.S. citizens who died while scuba diving abroad represented 17.4 percent of all fatalities recorded in 1995. In 1989 and 1990 there was an average of 25 foreign deaths. In 1992 and 1993, this percentage had decreased to 16 deaths, while there was an average of 22 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, and there were six fatalities in U.S. Territories during the 1980s. The cumulative totals by state and foreign location since 1980 are shown in Appendix C of this Report.

Fatality Dive Profile

Primary Dive Activities

Table 8.1 (below) shows the primary dive activity of the 104 divers who died in 1995. Most of the divers had at least open-water certification, but a number (n=14) were under instruction for either initial certification or to learn more advanced diving skills. Six divers had no record of any formal dive training and the level of training, if any, in seven other fatalities was not known. Most divers engage in diving activities that are compatible with their level of training and experience. Unfortunately, a minority of divers attempt to extend the limits of their diving skills and engage in specialty type dives (e.g., caves, wrecks, deep diving) without proper training or experience based on reports received at DAN. Each year a small number of people die while attempting to use scuba diving equipment without any formal training and often without proper equipment.

Of the 104 fatalties in 1995, 14 divers were under instruction for either initial certification or to learn more advanced diving skills.

Table 8.1 ***Primary Dive Activity***

Dive Activity	Certified	Uncertified	Unknown	Total	Percent
Pleasure	44	3	4	51	49.0
Under Instruction	14	0	0	14	13.4
Spearfishing/Hunting	10	1	1	12	11.5
Cave*	9	0	0	9	8.7
Work	4	2	0	6	5.8
Wreck*	4	0	0	4	3.8
Deep (> 130 feet)*	3	0	0	3	2.9
Unknown	1	0	2	3	2.9
Equipment Testing	1	0	0	1	1.0
Photography	1	0	0	1	1.0
TOTALS	**91**	**6**	**7**	**104**	**100.0**

**Technical dives*

Sightseeing and Instruction

Because most people scuba dive for sightseeing or pleasure, it is not surprising that the greatest number of the fatalities occur under these circumstances, accounting for nearly half of all fatalities in DAN's database over the years. As indicated in the table above, 14 fatalities occurred among divers under instruction, which is presumably a somewhat controlled environment.

Six of these students were in their initial open-water certification class, and the other eight were learning more advanced diving skills. The number of fatalities occurring in the instructional setting has increased each of the last two years.

Working Dives, Spearfishing, & Underwater Photography

DAN has placed very deep dives, wreck dives, and cave dives into the category of technical dives.

As explained in previous reporting years, a working dive for the purpose of DAN's database is a dive where scuba equipment is used to accomplish a specific dive-related or personal task. Military and commercial diving fatalities are not included in DAN's database and, truthfully, those numbers are extremely small. The working dives in DAN's fatality database include divers attempting to perform boat repairs, salvage lost personal gear, or free a fouled anchor line.

Nearly 10 percent of the recreational diving fatalities that occur each year involve divers who were either spearfishing or collecting lobster and other shellfish. One fatality occurred while the decedent was performing underwater photography, in contrast to four that occurred in 1994. DAN does not know if divers performing these types of activities are over-represented in the fatality figures. Divers should take extra caution when performing tasks that may divert their attention from fundamentally safe diving techniques.

Technical Dives

There is no universally accepted definition of what constitutes a technical dive or, for that matter, a technical diver. As noted earlier, the term "technical dive" as used in this report has been defined (page 64). As more divers look beyond traditional recreational scuba diving and employ newer and more advanced technology, divers using non-traditional gas mixes and equipment will make up a greater number of the fatalities. In this report, DAN has placed very deep dives, wreck dives, and cave dives into the category of technical dives. Sixteen deaths in 1995 occurred while the diver was performing one of these technical dives. While several of these involved divers who used gas mixtures other than air, and a few of these divers possessed special training or certification, the majority of these fatalities involved individuals who were either not properly trained or using appropriate equipment for the dive they were making.

Cave diving deaths increased from four in 1994 to nine in 1995, with several multiple-fatality incidents in 1995. Only three of these divers had formal certification in cave diving. The importance of acquiring experience and additional skills by seeking advanced training before performing one of these specialty dives cannot be overemphasized. Additionally, a specialty type of dive should never be attempted without proper equipment, which usually includes redundant emergency backup systems and safety devices.

Dive Entries-Shore, Boat, Pool

Table 8.2 shows the type of dive platforms used by divers involved in a fatal diving incident. In most years for which DAN has figures, a shore entry was utilized by nearly half of the dives with a fatal outcome. This figure dropped to 27.8 percent in 1994, but it was back up to nearly 40 percent in 1995. Charter- or private-boat diving made up a total of 58.6 percent of all scuba fatalities in 1995, which was down from 70.1 percent in 1994. As in 1994, there was one death in 1995 which involved a diver using scuba equipment in a swimming pool.

Table 8.2 *Dive Platform*

Entry	1995 Percent	1994 Percent	1993 Percent	1992 Percent	1991 Percent	1990 Percent
Shore	39.4	27.8	44.6	39.2	49.3	47.8
Charter Boat	35.5	30.9	32.6	26.8	28.4	30.4
Private Boat	23.1	39.3	20.6	29.9	20.9	20.7
Pool	1.0	1.0	1.1	1.0	1.5	0.0
Unknown	1.0	1.0	1.1	3.1	0.0	1.1
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Number of Divers in Groups Involving Fatalities

Table 8.3 (page 76) shows the number of divers listed in the dive group at the time of the fatality. As in previous years, the greatest number of fatalities occur during dives with two divers in the dive group. The percentage of fatalities occurring in dive groups containing both three divers or groups with more than 10 divers increased from 1994 to 1995. The most alarming figure is the number of fatalities that occurred while the decedent was diving alone — 15.4 percent in 1995. There were a few fatalities that occurred while the diver was with a large group but not diving with a designated buddy. Since every dive training organization emphasizes the need to dive with a buddy, all of these solo divers made what must be considered a gross violation of accepted safe diving procedures.

The most alarming figure is the number of fatalities that occurred while the decedent was diving alone — 15.4 percent in 1995.

Over 65 percent of diving fatalities occurred in groups of four or fewer divers. This figure may be used to argue the wisdom of diving in large groups, which is the custom of many European diving clubs. It must be taken into account, however, that in the United States many more dives take place with fewer than four divers in the group. The true incidence of fatalities occurring in large groups, compared to small groups of divers, cannot be determined with certainty.

Among fatalities reported in buddy divers, separation from the buddy was reported in over two-thirds of those fatalities.

Table 8.3 ***1995-Number of Divers in a Group***

Number in Dive Party	1995 Percent	1994 Percent	1993 Percent
1	15.4	6.2	5.4
2	20.2	22.7	25.0
3	17.3	16.5	10.9
4	12.5	11.3	9.8
5	2.9	6.2	8.7
6	4.8	6.2	4.3
7	1.9	2.1	2.2
8	1.9	2.1	3.3
9	1.0	2.1	1.1
≥10	18.3	15.5	15.2
Unknown	3.8	9.3	14.1
TOTAL	**100.0**	**100.2**	**100.0**

Of the divers who were buddy diving, separation from the buddy was reported in over two-thirds of those fatalities. While diving with a buddy may range from close contact throughout the dive to being in the same general area as a buddy, having another diver available to render assistance may mean the difference between life and death. Buddy separation eliminates the availability of immediate assistance and significantly increases the chance that a diver in distress will drown before making it to the surface.

When and Where in a Dive Problems Occurred

Tables 8.4 and 8.5 (page 77) show the approximate phase of the dive (*when*) and the area in the water column (*where*) the problem occurred that subsequently led to the fatality. This information is based upon witness accounts and investigative reports.

The predive and many of the post-dive events are frequently associated with pre-existing health problems such as cardiovascular disease. Incidents that occur on the surface prior to descent or early in the dive are often associated with malfunctioning or improperly assembled equipment. Most commonly, problems occurring late in the dive or during ascent arise from insufficient air. A total of nine fatalities were directly attributed to insufficient air, and running out of air was a contributing factor in several other cases. While several of these insufficient air fatalities were complicated by the diver having been entrapped in a cave or wreck, many of the fatalities occurred to divers who ran out of air in open water.

Table 8.4 ***When Problem Occurred***

	1995 Percent	1994 Percent	1993 Percent
Unobserved	32.7	23.8	9.8
Late Dive	20.2	29.9	31.5
Post Dive	16.3	20.6	16.3
Early Dive	11.5	11.3	15.2
Mid Dive	8.7	5.2	15.3
Surface - Predive	5.8	4.1	6.5
Unknown	2.9	4.1	4.3
Immediately	1.9	1.0	1.1
TOTAL	**100.0**	**100.0**	**100.0**
	n=104	*n=97*	*n=92*

Table 8.5 ***Where Problem Occurred***

	1995 Percent	1994 Percent	1993 Percent
Unobserved	32.7	16.5	12.0
Surface Post Dive	21.2	25.8	16.3
At Depth	15.4	29.8	32.6
During Ascent	14.4	16.5	22.8
Descent	7.6	4.2	5.4
Surface-Predive	5.8	4.1	6.5
Unknown	2.9	3.1	4.4
TOTAL	**100.0**	**100.0**	**100.0**
	n=104	*n=97*	*n=92*

Summary

To calculate the true incidence of diving accidents and fatalities, it is necessary to know how many uneventful dives occur each year. For 1995, as in previous years, this figure can only be estimated. DAN has initiated Project Dive Safety to more accurately determine the number of dives performed each year. Additionally, there are cases each year which provide little information about the incident or the body is not recovered. The large number of fatalities which involved divers who were in the water unaccompanied causes speculation on what may have gone wrong during those dives, but provides no factual data. The contributing factors and circumstances surrounding these fatalities are not known and cannot appear in DAN's figures.

A total of nine fatalities were directly attributed to insufficient air, and running out of air was a contributing factor in several other cases.

Dive Fatalities Among Certified Divers

In 1995, the greatest number of fatalities occurred in the 30- to 39-year-old age group.

This section reports on the certified divers and those who were students in an initial open-water certification course of instruction. The divers who had an unknown level of certification are included in this section, but the six uncertified divers have been excluded from the data presented here.

Age and Gender in Diver Fatalities

The ages and the gender for the 98 certified divers are shown in Table 9.1 (below). The 15 female fatalities represent 15.3 percent of all of the 1995 scuba deaths, compared to 29.5 percent in 1994. The percentage of female deaths in 1995 was more in line with what was observed in 1992 and 1993. This information will only truly become more meaningful when it is known know how many dives are made by women compared to men each year. The age range for female divers was 14 to 54 years of age; males ranged from 13 to 70 years of age. The age distribution is similar to that observed in the 1994 database, with the exception of an increase in deaths occurring in the 30- to 39-year-old group, with a compensatory decrease in the 20- to 29-year-old age group. The greatest number of fatalities occurred in the 30- to 39-year-old age group compared to 1994, when the 40- to 49-year-old group experienced the highest number of fatalities.

Table 9.1 *Age and Gender Comparison of 1995 Fatalities*

Age	Male	Female	Total	Percent
10 - 19	3	2	5	5.1
20 - 29	7	4	11	11.2
30 - 39	30	1	31	31.6
40 - 49	20	6	26	26.5
50 - 59	18	2	20	20.4
60 - 69	4	0	4	4.2
70 - 79	1	0	1	1.0
TOTAL	**83**	**15**	**98**	**100.0**

Certification Levels Among Fatalities

Table 9.2 shows the level of certification among 1995 scuba fatalities. The distribution is similar to that observed in the 1994 database, with the exception of a decrease from 63 percent to 54.1 percent of the deaths involving divers with only basic open-water certification. As has been reported in previous years, the result is comparable to certification analysis among those divers with DCI. While this may suggest that increased training could prevent many diving accidents, it is not known how many dives are completed by persons with only basic certification, compared to the number completed by divers with advanced training.

The number of deaths involving divers with cave diving and rescue diving certification doubled for each of those categories compared to last year. There was an increase in fatalities involving divers with advanced open-water certification compared to 1994. The increase in these three categories offset the decreased number of fatalities observed in the basic open-water certification group.

Compared to 1994 data, the number of deaths involving divers with cave diving and rescue diving certification doubled for each of those categories.

Table 9.2 *Certification Level of 1995 Fatalities*

Certification Level	Total	Percent
Open Water/Basic	53	54.1
Advanced	13	13.1
Unknown	10	10.2
Student*	6	6.1
Instructor	5	5.1
Cave Diver	4	4.2
Rescue	4	4.2
Commercial	1	1.0
Dive Master	2	2.0
TOTAL	**98**	**100.0**

* *Under initial training.*

Fatalities Grouped by Experience Levels

Table 9.3 (page 80) shows the experience level of all certified divers based upon the reported number of lifetime dives. The number is obtained from the information reported to DAN, which is not always exact and sometimes difficult to obtain. Some divers keep very meticulous logbooks while others merely estimate their number of lifetime dives, a figure which may not be known by dive partners or family members. The experience level in this table is indicated by categories containing a range of dives and designated by titles ranging from "novice" to "experienced."

Other indicators of diving experience include the number of years a diver has been certified and how many dives he or she has made during the preceding year. Unfortunately, in the majority of cases, this information is not known or is inexact. Another factor that can figure highly in diving mishaps is the diver's familiarity with the activity or environment.

Table 9.3 *Diving Experience in Fatalities*

	Overall Experience		Within Activity or Environment	
	Total	Percent	Total	Percent
Student	6	6.1	14	14.0
Novice (≤ 5 dives)	5	5.1	4	4.2
Inexperienced (6 - 20 dives)	23	23.5	24	24.5
Intermediate (21 - 40 dives)	14	14.0	10	10.2
Advanced (41 - 60 dives)	12	12.1	6	6.1
Experienced (≥ 61 dives)	29	30.0	23	23.5
No experience	0	0.0	8	8.3
Unknown	9	9.2	9	9.2
TOTAL	**98**	**100.0***	**98**	**100.0***

** Percent of certified divers / students*

In 1995, as in previous years, the most fatalities in any single experience group occurred among those divers with 61 or more dives.

Table 9.3 (above), which is divided into two major categories, reveals a great deal of information. "Overall Experience" refers to the total diving experience based on all known lifetime scuba dives. Experience Within Activity or Environment" refers to how experienced a diver was reported to have been in the specific activity (e.g., cave diving, deep diving, wreck diving, etc.) or environment (kelp bed, freshwater, etc.). This information is obtained by reviewing dive experience and dive history from investigative and witness reports.

As in previous years, the most fatalities in any single experience group occurred among those divers with 61 or more dives. When interpreting this figure, it must be kept in mind that this group represents the most active divers, who likely are logging the most bottom time each year. More experienced divers tend to engage in more challenging dive activities. DAN can only speculate on whether a certain level of complacency has resulted in any of the fatalities that occurred in the group of divers with the most experience. The greatest increase in deaths in any experience group occurred in the advanced, or 41-60 dives, group. It is probably more significant that deaths involving students doubled, from three to six, in 1995 compared to 1994.

The greatest increase in deaths among divers under the fatalities category "within activity or environment" occurred in the student group, which increased from four in 1994 to 14 fatalities in 1995. This group includes divers who were under instruction to learn how to dive in an environment with which they had no prior experience.

The greatest decrease in deaths was seen in the intermediate group, which had experienced a sharp increase in 1994 and returned to a figure similar to what was reported in 1993. For the past two years the inexperienced group has had the greatest number of fatalities in the "within activity or environment" category. It is possible that many divers are moving on to less familiar surroundings before obtaining a sound level of expertise in basic diving skills.

The greatest increase in deaths among divers under the category "within activity or environment" occurred in the student group.

Appendix A

1995 Fatality Case Reports with Autopsy Findings

By James Caruso, M.D., DAN On-Call Senior Staff Physician

Introduction/Overview

During the reporting year of 1995, the Divers Alert Network collected information on 104 scuba-diving related fatalities. A body was not recovered in nine of these cases, and no post-mortem examination was performed in 12 other cases. In 19 additional cases, an autopsy was performed but no, or only minimal, information regarding the findings of the post-mortem examination was available.

The purpose of this section is twofold. Describing factors which may have contributed to diving mishaps allows training agencies and other organizations involved in diver education to identify areas where increased training may result in the prevention of injury or death. Additionally, as diver education is a major function of Divers Alert Network, we hope that future mishaps may be averted by reviewing the circumstances associated with fatal outcomes.
5
As in previous years, the causes of death and the factors contributing to death in the DAN fatality case reports use the terminology of the International Classification of Diseases Clinical Modification (ICD-9-CM) based on the World Health Organization's International Classification of Diseases (1). The codes used frequently are listed in Appendix F.

The summaries and final anatomic diagnoses are arrived at by correlating all available information accumulated by DAN-including statements by witnesses and dive buddies, police and U.S. Coast Guard reports, DAN accident report forms, and the autopsy report. In most instances, the cause of death reported in the Fatality Case Report agrees with the conclusion arrived at by the medical examiner. In a select few cases, however, there is substantial historical or clinical evidence upon which an alternative cause of death can be based. The level of experience and familiarity with diving mishaps varies greatly among medical examiners and forensic pathologists.

The investigation of a diving fatality should include a minimum of the following information:

- The decedent's past medical history and any medications taken on a regular basis
- The decedent's level of training and diving experience
- Any witness statements on the victim's physical and emotional state on the day of the mishap
- The dive profile, including the depth and time of the dive, where and when the decedent began to run into difficulty, and any history of dives completed earlier in the day
- Resuscitation efforts and the decedent's response to therapy, if any
- The findings of a complete autopsy, including toxicology results
- The results of an examination of the decedent's equipment, including analysis of the breathing gas used, if available

Special techniques can be employed when performing a post-mortem examination on a suspected diving mishap victim. An autopsy protocol written by Kindwall and Pelligrini (2) was published in the 1992 *Report on Diving Accidents and Fatalities.* We have included a modified version of this protocol in Appendix B of this year's Report and recommend it be used as a guideline to performing a post-mortem examination on suspected diving mishap victims. Occasionally erroneous conclusions are drawn from obtaining air through a simple thoracic puncture or seeing bubbles distributed in the cerebral or coronary circulation. Intravascular gas is not pathognomonic (diagnostic) for air embolism or decompression sickness in the post-mortem examination of someone who has been breathing compressed air. All available pieces of information, especially the items listed above, should be taken into consideration before arriving at a conclusion regarding the cause of death in a diving fatality.

Because diving fatalities are at least initially catego-

rized as non-natural deaths, the medical examiner system assumes jurisdiction in most states. Autopsies are performed at the discretion of the local medical examiner and most diving fatalities are autopsied. It is recommended that an autopsy be performed in all diving fatalities and accidental drownings. The immediate cause of death in most diving fatalities is drowning, which is a diagnosis of exclusion. It can be argued that without a thorough post-mortem examination, many possible causes of death have not been excluded (3). For anyone interested in the risk factors for fatal diving incidents, the critical information is what events may have resulted in the drowning.

A total of 60 fatality case reports had an autopsy which was available to DAN for review. These cases appear in the following pages, categorized according to the immediate cause of death. Nineteen cases had an autopsy performed but the information is unavailable to DAN. Twelve cases did not have a post-mortem examination performed and nine cases involved fatalities where the bodies were never recovered. Four cases did not have enough information available to even speculate about the cause of death. These four groups are presented after the autopsy section and are separated into the same classifications as the autopsied cases.

AUTOPSIED CASES

A total of 60 fatality case reports with autopsy findings appear in the following sections. The autopsy provides essential information in establishing the cause of death in these cases. Divers are a self-selected group and epidemiological data on divers cannot be extrapolated to apply to the general population. We must, however, take note of commonly occurring errors in judgment and health problems that appear in these case reports.

Contributing Factors: Cardiovascular Disease and Inexperience

Two recurring themes were highlighted in last year's report and, based on the 1995 fatalities, are again worthy of separate mention. They are cardiovascular disease and diver inexperience.

Cardiovascular disease has been a significant cause of death in fatal diving mishaps for as long as DAN has been collecting data. This should come as no surprise since cardiovascular disease is the number one cause of death for both men and women in the United States and most other developed nations (4). The diver with atherosclerosis of the coronary arteries is at an increased risk for suffering a myocardial infarction or sudden cardiac death.

Of the 64 cases for which we have autopsy information, 20 included cardiovascular disease as the primary cause of death or the contributing factor which led to the primary cause of death. In several other cases, incidental coronary artery disease was noted during the post-mortem examination. While most recreational diving is not overtly strenuous, a certain amount of physical exertion is a routine component of a dive. When the dive does not go exactly as planned, a greater level of physical activity may be required for a diver to extricate him- or herself from a difficult situation. Additionally, most diving takes place in areas remote from tertiary medical care facilities and the mere fact that the diver is in the water makes surviving a cardiac event much less likely.

The message should be clear at this point. Diving should be considered a potentially strenuous activity and one that requires an adequate level of physical and cardiovascular fitness. An intelligent diver will follow a healthy diet, regularly engage in aerobic exercise, and obtain periodic medical evaluations. Older individuals who either desire to continue diving or wish to participate in an initial certification course should have a thorough physical examination with appropriate assessment of their cardiovascular status. An electrocardiogram and exercise treadmill test should be strongly encouraged.

Inexperienced divers were over-represented among the fatalities reviewed from 1991 through 1994 (5) and the same was true in 1995. Inexperienced divers include those who are in their initial open-water certification course and the newly certified divers who have 20 or less open-water dives after completing their training. This group has comprised 30 to 40 percent of the diving fatalities for the past two years. While Project Dive Safety is in its infancy, and we do not yet know the number of uneventful dives performed each year, it is safe to assume that the inexperienced divers are not making over 30 percent of all dives.

The number of certified, experienced divers who die while performing specialty dives (e.g., cave, wreck, deep dives) but do not have proper training or certification, as seen from reports sent to DAN, is always alarming. In 1995 there were nine fatalities that occurred during cave/cavern dives — only three of the decedents were certified cave divers. These specialty type dives require diving techniques and equipment that are not routinely covered in the initial open-water training course. The importance of proper training and a thorough familiarity with all equipment used during the dive cannot be overemphasized.

Summary of Fatality Data Collection

The primary reason for collecting and publishing the DAN fatality case studies is to help avoid future accidents. We can help educate ourselves and our fellow divers by sharing the lessons learned from the unfortunate experiences of others. We would like nothing more than to have this section of the Report be empty in future years. The best way to accomplish this goal is to advocate:

- physical fitness
- appropriate training and education
- proper and well-maintained equipment, and
- safe and conservative diving habits

Encouraging this awareness in divers of all levels, from novice to instructor, can help reach DAN's goal of safer diving for everyone.

The 1995 database of scuba diving fatalities can be found on the following pages.

Decompression Illness

The term decompression illness (DCI) includes the two bubble-related diseases most identified with diving — decompression sickness (DCS) and arterial gas embolism (AGE).

These disorders are grouped together because they are both characterized by:

- the presence of bubbles
- pressure change being required to produce the disease, and
- similar treatment

The 1995 autopsy series in the DAN database does not include any fatalities due to decompression sickness. This has not always been true in previous years, but the number of DCS fatalities is usually small. Decompression sickness can cause severe morbidity and even permanent paralysis, but it is rarely fatal. In contrast, there were four cases of death due to arterial gas embolism without drowning and four cases of AGE with drowning. In many cases, these were inexperienced divers and in most cases, insufficient air or panic were contributing factors. Inexperience is also a contributing factor that appears frequently in cases of divers who survive an arterial gas embolism (6).

Training on the causes and prevention of arterial gas embolism cannot be overemphasized during the initial open-water certification course. Divers must have a high level of comfort and familiarity with their equipment and emergency procedures should be second nature. There is seldom a good excuse for running out of air, and the results can be catastrophic.

Air Embolism

DAN RECORD NO: 695 **AGE:** 43 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Arterial gas embolism	958.0
Due to: Rapid ascent	E902.2
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Pneumothorax	860.0

Autopsy (Y/N): Y Findings available (Y/N): Y

A 43-year-old certified, but inexperienced, male diver was spearfishing in 100 fsw when he ran low on air. After signaling to his buddy that he was going to ascend, he ditched his dive gear and went up. The buddy surfaced a few minutes later to find the decedent unconscious on the surface. Resuscitation efforts were unsuccessful. The autopsy revealed air in the chest cavity and both ventricles of the heart. The postmortem interval was 24 hours. The pathologist erroneously emphasized the significance of the bubbles seen in the cerebral vessels and inferior vena cava, but the dive profile, evidence of pulmonary barotrauma, and clinical course make AGE the most likely cause of death.

DAN RECORD NO: 1195 **AGE:** 40 **SEX:** F **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Arterial gas embolism	958.0
Due to: Rapid ascent	E902.2
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Possible nitrogen narcosis	293.0

Autopsy (Y/N): Y Findings available (Y/N): Y

A 40-year-old woman was participating as a student in an advanced open-water certification class and made a shore entry during a night dive. Her dive was reported to be of 15 minutes duration and to a depth of 95 to 125 feet. She became separated from her buddy and made an emergency ascent due to running out of air. A witness reported her ascent as rapid. The diver was unconscious on the surface and could not be resuscitated. The autopsy report lists bubbles in both cerebral and coronary vessels. No special techniques were used, but the history and findings are consistent with an AGE.

DAN RECORD NO: 1995 **AGE:** 52 **SEX:** M **DIVER CAT:** R/T

Cause of Death	ICD-9-CM
Immediate: Arterial gas embolism	958.0
Due to: Rapid ascent	E902.2
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1. Coronary atherosclerosis	414.0

Autopsy (Y/N): Y Findings available (Y/N): Y

A 52-year-old experienced male diver was making a deep dive using trimix (oxygen, nitrogen, helium). He had no formal certification for trimix, but had used it in the past without incident. The decedent had a problem with his drysuit prior to the dive so he shut off the automatic dump. During descent the decedent's dive buddies stopped at 250 fsw, but he continued down to 307 fsw. Witnesses saw the decedent pop to the surface and resubmerge as his buddies made their decompression stops. The decedent's body was recovered an hour later. An autopsy was conducted 2 hours later and revealed extensive intravascular air with evidence of pulmonary barotrauma.

DAN RECORD NO: 2695 **AGE:** 37 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Arterial gas embolism	958.0
Due to: Rapid ascent	E902.2
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Coronary atherosclerosis	414.0
Significant Incidental Diagnoses	
1: Fatty liver	571.8

Autopsy (Y/N): Y Findings available (Y/N): Y

A 37-year-old male certified diver was making a dive on a wreck in 95 fsw with two other divers. The decedent became separated from his buddies and was witnessed to make an uncontrolled, rapid ascent before submerging back down into the water. He was found unconscious and on the bottom. Resuscitation efforts were unsuccessful and the autopsy demonstrated significant intracardiac gas.

LEGEND FOR FATALITY SUMMARIES

R - Recreational diver **T** - Technical diver
R/T - Recreational/Technical (diver conducting a technical dive that he/she is not qualified for)
UNC - Uncertified diver (a diver without a scuba certification from a national agency)

Drowning With Air Embolism

DAN RECORD NO: 995 **AGE:** 32 **SEX:** F **DIVER CAT:** U

Cause of Death	ICD-9-CM
Immediate: Anoxic encephalopathy	348.1
Due to: Drowning/nonfatal submersion	994.1
Due to: Arterial gas embolism	958.0
Due to: Recreational activity with diving equipment	E910.1

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

1: Pneumomediastinum	518.1
2: Pneumonia	486

Autopsy (Y/N): Y Findings available (Y/N): Y

A 32-year-old uncertified woman who had minimal familiarity with diving equipment was making a dive in 60 fsw with her boyfriend. The boyfriend was a certified diver as was the other diver in the group. The boyfriend experienced equipment problems and became separated from the decedent who also did not return with the third diver. The decedent was found on the surface 25 minutes later without her equipment and was taken to a hospital where she died two days later. An examination of the equipment revealed a malfunctioning, incorrectly rigged buoyancy compensator and a tank that was out of certification. The autopsy revealed cerebral edema and mastoid hemorrhages as well as pneumonia and mediastinal emphysema. The findings and dive history are most compatible with an AGE as the primary event, but this cannot be conclusively demonstrated two days after the mishap.

DAN RECORD NO: 6195 **AGE:** 38 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Air Embolism	958.0
Due to: Recreational activity with diving equipment	E910.1

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

1: Subcutaneous emphysema	958.7
2: Obesity	278
3: Alcohol abuse, acute (178 mg/dl, blood)	305.0
4: Nitrogen narcosis	293.0

Autopsy (Y/N): Y Findings available (Y/N): Y

A 38-year-old experienced diver was spearfishing with two other divers. He and one other diver were in a buddy team and at a depth of 91 fsw when the buddy signaled to the decedent to ascend. During the ascent, the decedent was noted to stop and head back toward the bottom. The other divers found the decedent on the bottom and brought him to the surface where resuscitation efforts were unsuccessful. The autopsy, which was performed the next day, disclosed extensive subcutaneous and intracardiac air. The intracardiac air can be a postmortem change, but the history combined with evidence of pulmonary barotrauma favor air embolism occurring during ascent.

DAN RECORD NO: 7595 **AGE:** 49 **SEX:** M **DIVER CAT:** UNC

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Air embolism	958.0
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): Y Findings available (Y/N): Y

This 49-year-old male was reportedly a frequent diver, but had no known formal certification. While he and a dive buddy were spearfishing, the buddy went to the surface because he was low on air. When the decedent did not surface at the expected time, a search was initiated and he was found on the bottom with his regulator out of his mouth. The medical examiner based her diagnosis of an air embolism on minimal evidence which included gas in the right side of the heart and superficial cerebral vessels. The history is not very typical for an air embolism except that the diver did run out of air.

DAN RECORD NO: 9795 **AGE:** 70 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Air embolism	958.0
Due to: Rapid ascent	E902.2
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): Y Findings available (Y/N): Y

A 70-year-old experienced male diver became separated at 90 fsw during an otherwise unremarkable dive. There is a report of possibly a rapid ascent, and the decedent was unconscious on the surface. He was placed on life support at a local hospital until brain death was determined. The autopsy was consistent with drowning, and the diagnosis of air embolism, which in this case is plausible, was based on the circumstances. The scuba tanks were not recovered during the rescue so a complete equipment check could not be performed.

Cardiovascular Disease

The problem of cardiovascular disease and how it applies to divers has been addressed in the introduction. Major risk factors for coronary artery disease include smoking, a diet high in cholesterol and saturated fats, male gender, hypertension, diabetes, and a family history of premature cardiovascular disease. The risk of developing cardiovascular disease increases with age as well. Unfortunately, cardiovascular disease can be clinically silent, and the first symptom may be sudden cardiac death.

Exertion increases the cardiac output and the need for more oxygen by the myocardium (heart muscle). If the vessels supplying blood (and ultimately oxygen) to the heart are narrowed due to disease, the result can be hypoxic damage or death of the tissue and, potentially, a short circuit in the electrical conduction of the heartbeat.

A diver with known cardiovascular disease needs to understand the potential increased risks and possible consequences of continuing to dive. Each individual needs to make an educated decision about his or her participation in any recreational activity. Many physicians who take care of divers will clear an individual who has undergone coronary bypass surgery for diving if the diver can remain asymptomatic while demonstrating a reasonable level of cardiovascular fitness. Older individuals who desire to continue diving or begin an initial certification course should have a thorough physical examination with an evaluation of their cardiovascular health.

In the following cases there are examples of individuals with silent cardiovascular disease which initially manifested itself during a dive with catastrophic results. Additionally, there are cases where the diver had known health problems which would be considered disqualifying for diving.

DAN RECORD NO: 1295 **AGE:** 67 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Cardiac dysrhythmia	427.9
Due to: Coronary atherosclerosis	414.0
Other significant conditions contributing to death but not resulting in the underlying cause	
1: Pulmonary emphysema	492.8
2: Chronic bronchitis	490
3: Obesity	278.0
4. Recreational activity with diving equipment	E910.1
Significant Incidental Diagnoses	
1: Fatty liver	571.8
2: Prostatic hypertrophy	222.2

Autopsy (Y/N): Y Findings available (Y/N): Y

A 67-year-old male made an uneventful dive to 35 fsw. His predive medications included decongestants and antibiotics, and he was a double amputee. Shortly after the dive he suffered a cardiac arrest and was taken to the hospital where he was

pronounced dead. The autopsy revealed focally severe coronary atherosclerosis as well as atherosclerosis of the cerebral arteries. The lungs showed chronic obstructive pulmonary disease and pulmonary edema. Incidental findings included a fatty liver and prostatic hypertrophy.

DAN RECORD NO: 1395 **AGE:** 43 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Cardiac dysrhythmia	427.9
Due to: Coronary atherosclerosis	414.0
Other significant conditions contributing to death but not resulting in the underlying cause	
1: Left ventricular hypertrophy	429.3
2: Fatty liver	571.8
3: Pulmonary edema	782.3
4: Obesity	278.0
5: Tobacco abuse	305.1
6. Recreational activity with diving equipment	E910.1

Autopsy (Y/N): Y Findings available (Y/N): Y

A 43-year-old obese male was in his initial open-water training course but had made approximately fifteen dives previously. The decedent told his friend that he felt light-headed and had pressure in his chest prior to the training sessions. He also had a history of fatiguing easily. During the second dive they were performing release maneuvers with their weight belts when the decedent was noted to be floating on his back and not breathing. Resuscitation efforts were unsuccessful, and the decedent was pronounced dead at a local hospital. The autopsy revealed severe coronary atherosclerosis and left ventricular hypertrophy. Moderate pulmonary edema as well as steatosis of the liver were also noted in addition to incidental cholelithiasis.

DAN RECORD NO: 4295 **AGE:** 53 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Coronary atherosclerosis	414.0
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Left ventricular hypertrophy	429.3
2: Obesity	278.0
3. Recreational activity with diving equipment	E910.1

Autopsy (Y/N): Y Findings available (Y/N): Y

A 53-year-old male certified diver was reacquainting himself with his dive equipment in a swimming pool. The decedent had not gone diving in three years and was reportedly using far more weight than he should have needed. There were no other people in the area. The autopsy lists the cause of death as occlusive coronary atherosclerosis, but all coronary arteries were at least 50 percent patent. The cause of death could just as easily have been drowning.

DAN RECORD NO: 5095 **AGE:** 50 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Cardiac dysrhythmia	427.9
Due to: Coronary artery disease, severe	414.0
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Left ventricular hypertrophy	429.3
2: Obesity	278.0
3. Recreational activity with diving equipment	E910.1
Significant Incidental Diagnoses	
1: Fatty liver	571.8

Autopsy (Y/N): Y Findings available (Y/N): Y

A 50-year-old male who possibly had some history of asthma was a student in an advanced open-water course doing his check-out dives. He was witnessed to ascend quickly and then became unconscious at the surface. Resuscitation efforts were unsuccessful. The history is good for air embolus, but the autopsy disclosed severe coronary artery disease and no evidence of pulmonary barotrauma or air embolus.

Drowning With Cardiovascular Disease
Contributing or Present

DAN RECORD NO: 295 **AGE:** 41 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1

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

1: Left ventricular hypertrophy	429.3
2: Obesity	278.0

Autopsy (Y/N): Y Findings available (Y/N): Y

A 41-year-old male student in an advanced open-water diving class had made ten total dives previously. After twenty minutes at 28 fsw he panicked and surfaced unexpectedly. The instructor found him unconscious at the surface and resuscitation was unsuccessful. The autopsy was consistent with drowning and additionally showed left ventricular hypertrophy and cholelithiasis. A cardiac dysrhythmia cannot entirely be ruled out.

DAN RECORD NO: 1095 **AGE:** 43 **SEX:** F **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Cardiac dysrhythmia	427.9
Due to: Left ventricular hypertrophy	429.3

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

1: Diabetes mellitus	250.0
2: Obesity	278.0

Autopsy (Y/N): Y Findings available (Y/N): Y

A 43-year-old female with several medical problems was participating in an initial open-water certification class. In 30 fsw she and her partner were practicing buddy breathing when she began to experience difficulty and ascended. On the surface she had difficulty breathing then suffered a cardiopulmonary arrest. Advanced Cardiac Life Support (ACLS) was provided with unsuccessful results. The autopsy revealed left ventricular hypertrophy and some dysplasia of the right ventricle. The liver had moderate fatty change.

DAN RECORD NO: 1595 **AGE:** 32 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Cardiac dysrhythmia	427.9
Due to: Chronic myocardial ischemia	414.9
Due to: Coronary atherosclerosis	414.0

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

1: Diabetes mellitus	250.0
2: Obesity	278.0
3: Hypertension	401.9
4: Left ventricular hypertrophy	429.3
5: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): Y Findings available (Y/N) : Y

A 32-year-old male diver with advanced open-water certification was making a freshwater dive at altitude. He had several medical problems including diabetes and a history of colon cancer. The decedent went to a maximum depth of 126 feet which was a new personal record and the rest of the dive was spent in shallower water. He signaled to his buddy to ascend, but the buddy noticed that the decedent did not follow him up. The body was recovered from the bottom. The autopsy revealed coronary atherosclerosis and diffuse myocardial fibrosis as well as hypertrophy of the left ventricle.

LEGEND FOR FATALITY SUMMARIES
R - Recreational diver **T** - Technical diver
R/T - Recreational/Technical (diver conducting a technical dive that he/she is not qualified for)
UNC - Uncertified diver (a diver without a scuba certification from a national agency)

DAN RECORD NO: 2295 **AGE:** 51 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Anoxic encephalopathy	348.1
Immediate: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Coronary atherosclerosis, severe	414.0
2: Chronic obstructive pulmonary disease	496.0
3: Obesity	278.0

Autopsy (Y/N): Y Findings available (Y/N): Y

A 51-year-old male with a history of asthma and hypertension was making his third dive after completing an initial open-water certification course. He was seen using his prescription inhaler prior to the dive. After a 30-minute dive to 35 fsw, the decedent began to have difficulty during a surface swim back to shore. The decedent's dive buddy noticed the diver was floating on the surface and unconscious. After initial resuscitation, the diver expired the next day in a hospital intensive care unit. The decedent had weights in the pockets of his buoyancy compensator and his depth gauge was malfunctioning. The autopsy revealed both evidence of drowning and significant natural disease processes.

DAN RECORD NO: 5495 **AGE:** 31 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Coronary atherosclerosis	414.0
2: Panic	308.0
3: Obesity	278.0

Autopsy (Y/N): Y Findings available (Y/N): Y

A 31-year-old male diver was making his second dive of the day in a freshwater lake. The decedent was noticed to be experiencing difficulty and the instructor signaled for the divers to surface. His buddy attempted to give her octopus to him, but the decedent panicked and tried to grab her primary regulator. He was then assisted to shore where resuscitation efforts failed. The decedent's certification level and experience are unknown. In addition to coronary artery disease, the autopsy revealed the presence of therapeutic levels of several medications used in the treatment of severe psychiatric disorders.

DAN RECORD NO: 6095 **AGE:** 57 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Coronary atherosclerosis (severe)	414.0
2: Pulmonary emphysema	492.8

Autopsy (Y/N): Y Findings available (Y/N): Y

A 57-year-old male was found unconscious and on the bottom while scuba diving. His certification level and diving experience are unknown. The autopsy revealed severe coronary artery disease with near total occlusion of one of the coronary arteries.

DAN RECORD NO: 6495 **AGE:** 32 **SEX:** M **DIVER CAT:** T

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Left ventricular hypertrophy	429.3
2: Obesity	278.0
Significant Incidental Diagnoses	
1: Splenomegaly	789.2

Autopsy (Y/N): Y Findings available (Y/N): Y

A 32-year-old very experienced male diver made a deep nitrox (36 percent) dive under instruction. The maximum depth of the dive was 215 feet. The diver reportedly had some difficulty with his drysuit and buoyancy. During ascent, the decedent became separated from his buddy at approximately 160 feet. The body was recovered three days later at a depth of 231 feet using a remote-operated salvage vehicle. The autopsy was consistent with drowning and showed intravascular bubbles and cystic areas in the brain which would be expected findings in long, deep dives. It cannot be determined if narcosis played a factor since the diver's equipment was in good working order and the gas mixtures, if used correctly, would have limited the chance of narcosis. Oxygen toxicity using nitrox at these deep depths is also a possibility.

DAN RECORD NO: 7195 **AGE:** 42 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Coronary atherosclerosis/chronic myocardial ischemmia	414.0
2: Left ventricular hypertrophy	429.3
3: Remote myocardial infarct	410.0
4: Remote cerebral contusion	851.8
5: Propoxyphene on toxicology	E935.8
6: Hydrocodone on toxicology	E935.2

Autopsy (Y/N): Y Findings available (Y/N): Y

A 42-year-old male with extensive diving experience and nitrox certification was lobster hunting in a large group but without an identified dive buddy. When the decedent did not return with the group, a search was initiated. The decedent was using a dive buoy, but that was found tied off to a weight. His body was recovered two hours later on the bottom. The decedent had a significant past medical history which included a myocardial infarction followed by insertion of a pacemaker because of a syncopal episode within the past year. Toxicology was positive for hydrocodone, propoxyphene, and diphenhydramine. The autopsy revealed extensive evidence of natural disease and the diver's tank was empty.

DAN RECORD NO: 7895 **AGE:** 52 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Coronary atherosclerosis	414.0
2: Obesity	278.0
3: Fatty liver	571.8

Autopsy (Y/N): Y Findings available (Y/N): Y

A 52-year-old, experienced, frequent diver was lobster hunting during the first day of the new season. He entered the water with two other divers but then separated to go off on his own. After an hour, the other divers searched for the decedent, and he was found on the bottom with the regulator in his mouth but not breathing. Resuscitation efforts were unsuccessful. The autopsy disclosed severe coronary atherosclerosis which was previously undiagnosed. It is possible that the diver suffered a fatal dysrhythmia in the water.

DAN RECORD NO: 7995 **AGE:** 44 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Coronary atherosclerosis	414.0
2: Obesity	278.0
3: Tobacco abuse	305.1
Significant Incidental Diagnoses	
1: Multiple capillary hemangiomas, liver	228.04

Autopsy (Y/N): Y Findings available (Y/N): Y

A 44-year-old male certified diver with a moderate amount of diving experience made repetitive dives to 40 fsw with a large group. Twenty minutes into the third dive he was seen briefly on the surface before submerging again. Divers found the decedent's body nearly two hours later. In addition to coronary artery disease, the autopsy disclosed blood in one ear canal without an obvious perforation of the tympanic membrane.

DAN RECORD NO: 8295 **AGE:** 52 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Coronary atherosclerosis	414.0
2: Left ventricular hypertrophy	429.3
Significant incidental diagnoses	
1: Nephrolithiasis	592.0

Autopsy (Y/N): Y Findings available (Y/N): Y

A 52-year-old male, inexperienced, certified diver was making his first dive of the season with two other divers. The first dive was a bounce to 100 feet for five minutes followed by a repetitive dive to 75 feet. The dives were made in a flooded mine and visibility was suboptimal. The decedent had some difficulty equalizing pressure in his ears, but otherwise he did not experience any witnessed problems. During the second dive, the decedent became separated from the other two divers. They found him unconscious and brought him to the surface where resuscitation efforts were unsuccessful. The autopsy disclosed focally severe coronary atherosclerosis, and the findings were consistent with drowning.

DAN RECORD NO: 8395 **AGE:** 53 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Coronary atherosclerosis, severe	414.0
2: Panic	308.0
3: Tobacco abuse	305.1
Significant Incidental Diagnoses	
1: Fatty liver	571.8
2: Benign prostatic hypertrophy	222.2

Autopsy (Y/N): Y Findings available (Y/N): Y

A 53-year-old male certified diver was making a shallow dive with his wife as a dive buddy. He noticed that he was low on air and surfaced near the wrong boat. The decedent was noted to be struggling on the surface and panicked as he fought the current. He was brought to the boat and resuscitation efforts were initiated. The decedent's condition deteriorated and he was pronounced dead at a local hospital. The autopsy was consistent with drowning, but a cardiac event cannot be ruled out given the extent of the coronary disease.

DAN RECORD NO: 8495 **AGE:** 35 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Coronary atherosclerosis	414.0
2: Left ventricular hypertrophy	429.3
3: Obesity	278.0
4: Tobacco abuse	305.1
5: Cannibinoids	E980.3
Significant Incidental Diagnoses	
Horseshoe kidney anomaly	753.3

Autopsy (Y/N): Y Findings available (Y/N): Y

A 35-year-old male certified diver with minimal diving experience made a shore entry and a long surface swim with his dive buddy. The dive buddy noticed that the decedent was having difficulty on the surface and appeared to be swallowing water.

They decided to head back to shore using their regulators, but the decedent continued to struggle and did not have his regulator in his mouth when the buddy came to his aid. The dive buddy pulled the decedent to shore where resuscitation efforts were unsuccessful. The autopsy disclosed evidence of cardiovascular disease which possibly was a significant factor in this fatal dive profile.

DAN RECORD NO: 8795 **AGE:** 42 **SEX:** F **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Obesity	278.0
2: Coronary atherosclerosis, mild	414.0
Significant Incidental Diagnoses	
1: Medullary carcinoma of the thyroid gland	193.0
2: Adrenal cortical adenoma	227.0
3: Fatty liver	571.8

Autopsy (Y/N): Y Findings available (Y/N): Y

The decedent was a 42-year-old, inexperienced female diver and was making a dive with her husband and 13-year-old daughter. After 11 minutes at 71 fsw, the daughter was having some difficulty, and they all ascended. The divers had surfaced far from the charter boat in a stiff current and moderately rough seas. The divemaster entered the water and swam to the divers to render assistance. After the divemaster inflated the buoyancy compensator of all three divers, he assisted them back to the boat. The decedent was severely fatigued and required the most assistance. During the swim back to the boat, she became unconscious. Resuscitation efforts were unsuccessful. In addition to changes consistent with drowning, the autopsy disclosed several natural disease processes.

DAN RECORD NO: 9095 **AGE:** 45 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Coronary atherosclerosis, severe	414.0
2: Tobacco abuse	305.1

Autopsy (Y/N): Y Findings available (Y/N): Y

A 45-year-old male certified diver with a fair amount of diving experience made a dive to 54 fsw for 25 minutes. The decedent was in poor physical shape and was trying out new equipment. He apparently had some difficulty with his drysuit and was witnessed to be floating with his feet up. The diver was brought back to the boat, but resuscitation efforts failed. The autopsy was consistent with drowning and additionally revealed severe coronary artery disease.

DAN RECORD NO: 9295 **AGE:** 64 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Coronary atherosclerosis/Chronic myocardial ischemia	414.0
2: Atherosclerosis of the cerebral arteries	437.0
Significant Incidental Diagnoses	
1: Fatty liver	571.8

Autopsy (Y/N): Y Findings available (Y/N): Y

A 64-year-old male with a moderate amount of diving experience made a wreck dive from a charter boat with a large group of divers. After spending nearly 40 minutes at 90 fsw, the group returned to the boat. The decedent was noticed to be missing, and a search of the bottom found him unconscious on the deck of the wreck. After an hour of CPR, the diver was pronounced dead at the closest hospital. The decedent had a history of ischemic heart disease and was on diltiazem. The autopsy revealed atherosclerosis of the coronary and cerebral arteries. The other findings were consistent with drowning.

Drowning With Medical Condition Present Excluding Cardiovascular Disease

There are various medical conditions that have been traditionally associated with an increased risk of morbidity and mortality in divers. Because of the relatively small number of diving fatalities associated with each of these medical conditions, meaningful statistical analysis is difficult to perform. Conditions which were once felt to be unequivocally disqualifying for diving, such as asthma and diabetes, have been open to increased debate during the past few years. The question of what constitutes adequate fitness to dive is complex, and the diver, in consultation with his or her health care provider, must make an informed decision based upon the available information in the literature.

The following cases include diving fatalities where there was evidence of a chronic health problem present, some of which could arguably be medically disqualifying for diving. Some medical conditions, such as obesity or a physical impairment, may have a direct effect on the diver's performance in the water. Other conditions, such as a seizure disorder, impart a theoretical, if not real, increased risk of the diver having a problem in the water. Additionally, while the medical condition may not in itself interfere with safe diving, the side effects of a medication taken for a health problem may impair the diver's ability to function optimally.

Cases present in the DAN fatality data base every year that are always disturbing include those where the diver was under the influence of alcohol or other drugs. Diving requires clear thinking and occasionally rapid reaction times. An impaired diver may make poor decisions regarding his or her dive plan or be unable to provide emergency assistance to a dive buddy.

DAN RECORD NO: 3395 **AGE:** 19 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Panic	308.0
Significant Incidental Diagnoses	
1: Patent foramen ovale	745.5

Autopsy (Y/N): Y Findings available (Y/N): Y

A 19-year-old male received his initial open-water certification two days prior to this fatal diving incident. The decedent was at 60 fsw when he signaled to his buddy that he was having some difficulty with his air source. The dive buddy offered the decedent his octopus, but he spit it out shortly after putting it in his mouth. The decedent then grabbed his dive buddy's primary regulator, and the buddy broke away and headed for the surface. The divemaster entered the water and pulled the unconscious diver from off the bottom. Resuscitation efforts were unsuccessful. The autopsy findings were consistent with drowning. The decedent's tank contained sufficient air and his equipment was in adequate working condition.

DAN RECORD NO: 5295 **AGE:** 44 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Dilated cardiomyopathy	425.4
2: Left ventricular hypertrophy	429.3
3: Diabetes mellitus	250.0
4: Cirrhosis	571.2
5: Sarcoidosis (mild pulmonary involvement)	517.8
6: History of depression	296.9

Autopsy (Y/N): Y Findings available (Y/N): Y

A 44-year-old, obese, insulin-dependent diabetic male with minimal diving experience went into the water without a dive buddy. Witnesses recall the diver making a shore entry and his body was found on the surface later that same day. The autopsy disclosed evidence of numerous chronic disease processes.

DAN RECORD NO: 6395 **AGE:** 44 **SEX:** F **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1
Significant Incidental Diagnoses	
1: Scoliosis	754.2

Autopsy (Y/N): Y Findings available (Y/N): Y

A 44-year-old female certified diver began to have some difficulty while making her second dive of the day. Her husband attempted to assist her, but she became unconscious and resuscitation efforts were unsuccessful. The autopsy was consistent with drowning.

DAN RECORD NO: 9195 **AGE:** 35 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Acute alcohol intoxication (113 mg/dl)	305.0
2: History of depression	296.9

Autopsy (Y/N): Y Findings available (Y/N): Y

A 35-year-old certified diver had a history of depression including two previous suicide attempts. One prior incident included an attempted suicide while diving at the same location where his final dive occurred. He was diving alone in an area where the water reaches depths exceeding 180 fsw. When his equipment was recovered, the dive watch indicated a bottom time of 54 minutes, but the maximum depth on the gauge had been exceeded. The decedent's equipment, including an empty tank, was found several days after he disappeared. The body was found 17 days later.

DAN RECORD NO: 9695 **AGE:** 42 **SEX:** M **DIVER CAT:** UNC

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Affective disorder (depression)	296.9
2: Alcohol use (blood alcohol level was 21 mg/dl)	305
3: Benzodiazepine use	E934.4
4: Codeine use	E935.2
Significant Incidental Diagnoses	
1: Fatty Liver	571.8

Autopsy (Y/N): Y Findings available (Y/N): Y

A 42-year-old uncertified diver made a dive alone in an attempt to try out the equipment. He was on prescription medication for depression. Witnesses report the decedent first attempted to attach an empty tank to his regulator before switching to a full tank. The incident in the water was not witnessed, but the decedent's equipment was reported to be assembled incorrectly. The autopsy findings were consistent with drowning and toxicology was positive for antidepressants, codeine, morphine, and benzodiazepines.

LEGEND FOR FATALITY SUMMARIES

R - Recreational diver **T** - Technical diver

R/T - Recreational/Technical (diver conducting a technical dive that he/she is not qualified for)

UNC - Uncertified diver (a diver without a scuba certification from a national agency)

Drowning Due to Insufficient Air

The following cases shared the common factor of the diver running out of air or other gas used for the dive. Cases where insufficient breathing media contributed to the fatality, especially when the diver was entrapped, have been placed in other categories. The nine cases that follow represent the most obvious instances of fatality due to the diver running out of air.

DAN RECORD NO: 3195 **AGE:** 59 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Obesity	278.0
2: Tobacco abuse	305.1
3: Coronary atherosclerosis	414.0
Significant Incidental Diagnoses	
1: Nephrosclerosis	403.9
2: Fatty liver	571.8

Autopsy (Y/N): Y Findings available (Y/N): Y

A 59-year-old male made two dives in a large group to do some underwater photography. Twenty minutes into the second dive he signaled to his buddy that he was low on air and heading to the surface. The dive buddy found the decedent unconscious and on the surface. Resuscitation efforts were unsuccessful. The decedent's regular medications included codeine, inhaled steroids and decongestants, but toxicology was negative. His tank contained minimal air, and the autopsy findings were consistent with drowning.

DAN RECORD NO: 3595 **AGE:** 33 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): Y Findings available (Y/N): Y

A 33-year-old male with a moderate amount of diving experience made a shore entry dive without a buddy. When the decedent did not show up for work, a search was initiated, and the body was found by a recreational diver one month later. The autopsy and toxicology studies were unrevealing. The depth gauge showed a maximum depth of 90 fsw, and the decedent's tank was empty.

DAN RECORD NO: 3795 **AGE:** UNK **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Paralysis of lower extremities	344.1

Autopsy (Y/N): Y Findings available (Y/N): Y

A certified diver with extensive diving experience had continued to dive after an accident that left him without use of his lower extremities. He reportedly had been complaining of frequent muscle cramps recently. The decedent had friends drop him off in an area no deeper than 20 fsw so that he could dive while they fished nearby. After twenty minutes, the decedent's friends returned to the area and noticed that the diver was unconscious and floating beneath the surface of the water. The decedent was quickly pulled into the boat, but resuscitation efforts were unsuccessful. The decedent was diving without a buddy and his equipment was reported to be in poor repair. The autopsy was reported to show findings consistent with drowning.

DAN RECORD NO: 4095 **AGE:** 34 **SEX:** M **DIVER CAT:** R/T

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1

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

1: Benzodiazepine use (toxicology)	E934.4
2: Phenobarbital use (toxicology)	E937.0
3: Diphenhydramine use (toxicology)	E933.0

Significant Incidental Diagnoses

1: Hepatitis B infection	070.3

Autopsy (Y/N): Y Findings available (Y/N): Y

This was a 34-year-old extremely experienced diver who drowned while attempting to rescue his son during the diving incident described in the following report. The decedent's air source had been exhausted, and the autopsy was consistent with drowning.

DAN RECORD NO: 4195 **AGE:** 14 **SEX:** M **DIVER CAT:** R/T

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1

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

1: Panic	308.0
2: Nitrogen narcosis	293.0

Autopsy (Y/N): Y Findings available (Y/N): Y

A 14-year-old certified diver with minimal diving experience made a wreck dive to 140 fsw with his father and several other divers. After the group completed an initial, uneventful, first dive, it was determined that the anchor was entangled on the wreck. It was decided to make the second dive of the day on the same wreck and free the anchor in the process. Five divers descended to the wreck in an unsuccessful attempt to free the anchor. During ascent, the decedent motioned to another diver that he was out of air. While the two divers were buddy breathing off of the assisting diver's backup air source, the decedent was unable to continue the ascent due to being overweighted. The spare air ran out and the assisting diver lost consciousness as he headed to the surface. The decedent's father, who had recently exited the water, went back down to assist his son. Both the father and son were found unconscious at 140 fsw and were pronounced dead at the recompression chamber. The autopsy on the son was consistent with drowning. Large amounts of intravascular gas was present, but the postmortem examination was conducted three days after the death occurred. The diver who had rendered assistance was treated for a possible gas embolism, and the two other divers in the water at the time required treatment for symptoms of decompression sickness.

DAN RECORD NO: 5595 **AGE:** 44 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Insufficient air	E913.2
Due to: Entanglement (kelp)	E918.4

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

1: Pulmonary emphysema	492.8
2: Panic	308.0
3: Tobacco abuse	305.1

Autopsy (Y/N): Y Findings available (Y/N): Y

A 44-year-old male certified diver who hadn't made a dive in eight years was diving with his son. During the second dive of the day he became entangled in kelp and panicked. His son tried unsuccessfully to render assistance and then surfaced for help. The decedent was brought to the surface after several attempts, but resuscitation was unsuccessful. The autopsy was consistent with drowning. There was an isolated finding of air in the left ventricle, but the postmortem examination was conducted four days after death. An equipment evaluation showed the decedent had an empty tank and did not use a pressure gauge.

DAN RECORD NO: 9395 **AGE:** 28 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Anomalous right coronary artery	746.85
2: Acute alcohol intoxication	305.0
Significant Incidental Diagnoses	
1: Patent foramen ovale	745.5

Autopsy (Y/N): Y Findings available (Y/N): Y

A 28-year-old male who had not made a dive in five years was diving alone in a local lake while his wife followed his bubbles in a small boat. The decedent wore jeans and a T-shirt and placed lead weights in his pockets. At one point he surfaced in distress and stated he was out of air. When the diver submerged again his wife called for help. Searchers found the decedent's body four hours later in 11 feet of water. The autopsy revealed an anomolous takeoff (abnormal anatomy) of the right coronary artery which can occasionally cause sudden death. The decedent had sought medical care two weeks earlier for chest pain. The most likely scenario in this case, however, is drowning secondary to insufficient air in the setting of acute alcohol intoxication.

DAN RECORD NO: 9895 **AGE:** 20 **SEX:** M **DIVER CAT:** R/T

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): Y Findings available (Y/N): Y

A 20-year-old male was diving in a deep freshwater cavern system with two other divers. One of the other divers had training in cave diving, but the decedent did not. They made a dive to a maximum depth of 89 feet for a bottom time of 64 minutes. On ascent, one of the buddies ran out of air and used the other diver's octopus. At the surface, they realized that they should have made a decompression stop and descended to 10 feet for two minutes. During this time the decedent also ran out of air and began buddy breathing with the octopus. They ascended again, but at the surface the decedent was noted to be still down at the 10 foot mark. He was brought to the surface where resuscitation efforts were unsuccessful. The autopsy did not show evidence of pulmonary barotrauma or AGE.

DAN RECORD NO: 9995 **AGE:** 47 **SEX:** F **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Obesity	278.0
2: Coronary atherosclerosis	414.0

Autopsy (Y/N): Y Findings available (Y/N): Y

A 47-year-old inexperienced certified female diver made a dive to 60 fsw with a buddy. At the 15 minute mark, the decedent ran out of air and used the octopus of her dive buddy. She had trouble ascending and her buddy attempted to remove her weight belt, but it was caught in her equipment. The dive buddy reports that the ascent was controlled, and the decedent initially seemed fine at the surface but quickly became unconscious. The decedent was treated with a USN TT6A with extensions, but was pronounced dead at a nearby hospital. The autopsy did not disclose evidence of an air embolus, although the treatment would have eliminated intravascular air. The history is suspicious for an AGE.

Drowning / Accident

DAN RECORD NO: 195 **AGE:** 39 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1

Other significant conditions contributing to death but not resulting in the underlying cause:
1: Panic 308.0
Autopsy (Y/N): Y Findings available (Y/N): Y
A 39-year-old male was a student in an initial open-water diving class. His leg became entangled in a rope and he panicked. When the instructor attempted to assist the decedent, the instructor was grabbed and nearly drowned. A third person rendered assistance and the decedent did not respond to emergency resuscitation efforts. There was a possible problem with the buoyancy compensator and the decedent was likely overweighted.

DAN RECORD NO: 595 **AGE:** 30 **SEX:** M **DIVER CAT:** R/T
Cause of Death ICD-9-CM
Immediate: Drowning/nonfatal submersion 994.1
Due to: Recreational activity with diving equipment E910.1
Autopsy (Y/N): Y Findings available (Y/N): Y
A 30-year-old male with moderate diving experience but no formal cave diving training made a dive in a flooded mine shaft at altitude without a dive buddy. He did not use a safety line and was witnessed to ascend twice during the dive. The maximum water depth was 45 feet and sheriffs' divers recovered the decedent's body. One thousand psi of air remained in the tank. The autopsy was consistent with drowning.

DAN RECORD NO: 895 **AGE:** 56 **SEX:** M **DIVER CAT:** U
Cause of Death ICD-9-CM
Immediate: Drowning/nonfatal submersion 994.1
Due to: Recreational activity with diving equipment E910.1
Autopsy (Y/N): Y Findings available (Y/N): Y
A 56-year-old man was using borrowed diving equipment to do some maintenance on the underside of his boat. The boat was attached to a dock and in 10 feet of water. He was not a certified diver, but had used borrowed equipment several times previously. A witness noticed an absence of bubbles at the surface and the body was recovered by police divers. The autopsy revealed pulmonary edema and was consistent with drowning. Incidental pulmonary hamartomas were noted.

DAN RECORD NO: 3295 **AGE:** 31 **SEX:** M **DIVER CAT:** R
Cause of Death ICD-9-CM
Immediate: Drowning/nonfatal submersion 994.1
Due to: Recreational activity with diving equipment E910.1
Autopsy (Y/N): Y Findings available (Y/N): Y
A 31-year-old advanced open-water diver made a shore entry into the ocean with his dive buddy. The buddy did not have enough weight to descend so he returned to shore while the decedent waited. The decedent was noted to go beneath the surface, and the buddy waited on shore until the decedent would surface so he could join him. The decedent's body was found six hours later on the bottom. He had a snorkel in his mouth and a full tank of air. He was also overweighted for his body size. The autopsy was consistent with drowning.

DAN RECORD NO: 3695 **AGE:** 36 **SEX:** M **DIVER CAT:** R
Cause of Death ICD-9-CM
Immediate: Drowning/nonfatal submersion 994.1
Due to: Recreational activity with diving equipment E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:
1: Cannabinoid use E980.3
Autopsy (Y/N): Y Findings available (Y/N): Y
A 36-year-old male certified diver with significant diving experience was making a dive with three others in the open ocean. There was a strong current and the sea state was rough. As the divers attempted to descend down the anchor line, their efforts were hampered by the current, and they became separated. Three of the four divers surfaced and they were assisted back to their boat by a nearby fishing vessel. When the decedent did not surface, a search was initiated. The decedent's body was recovered three days later and his tank was noted to be nearly full.

LEGEND FOR FATALITY SUMMARIES
R - Recreational diver **T** - Technical diver
R/T - Recreational/Technical (diver conducting a technical dive that he/she is not qualified for)
UNC - Uncertified diver (a diver without a scuba certification from a national agency)

DAN RECORD NO: 4795 **AGE:** 32 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): Y Findings available (Y/N): Y

A 32-year-old experienced diver was in shallow water performing salvage operations on boats that had been damaged in a recent hurricane. Little information is available regarding the events of the dive, but the decedent's buddy surfaced first because he was low on air. The decedent did not surface at the expected time. The autopsy was consistent with drowning, and toxicology was negative. The status of the decedent's equipment and whether or not there was air left in his tank are unknown.

DAN RECORD NO: 5695 **AGE:** 35 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1

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

1: Tobacco Abuse	305.1

Autopsy (Y/N): Y Findings available (Y/N): Y

A 35-year-old male who was a certified diver went out with a large group of divers on a commercial dive charter. At the beginning of the dive, the decedent's buddy had a problem with his weight belt and returned to the boat. The decedent continued on the dive alone, but did not return with the rest of the group. He was found unconscious and on the bottom with the regulator out of his mouth and a nearly full tank of air. The autopsy was consistent with drowning.

DAN RECORD NO: 7495 **AGE:** 20 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): Y Findings available (Y/N): Y

A 20-year-old very experienced male diver made a night dive to hunt for lobster. He did not dive with a buddy and had a medical history significant for seizures five years earlier. After the diver was reported missing, a search was initiated and the body was found by rescue divers. The autopsy findings were consistent with drowning. The possibility of a seizure prior to drowning was raised by investigators, although there is no definitive proof of this.

DAN RECORD NO: 8195 **AGE:** 34 **SEX:** M **DIVER CAT:** R/T

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1

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

1: Nitrogen narcosis	293.0

Autopsy (Y/N): Y Findings available (Y/N): Y

A 34-year-old certified diver was diving with a buddy in an area where an underwater canyon was located. The divers had little experience in making deep dives, and they each used a single tank containing air. The buddy team inadvertently found themselves at 198 fsw with limited air and feeling the effects of narcosis. As they ascended, the divers became separated at 120 fsw and the dive buddy surfaced and called for help. The decedent's body was not found until 38 days later. Autopsy findings were limited due to the length of time the body had been in the water.

DAN RECORD NO: 10495 **AGE:** 65 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): Y Findings available (Y/N): Y

This 65-year-old male entered the water without a dive buddy in order to retrieve a ladder he had lost in this area previously. The area had a maximum depth of 20 feet and the current was strong. The diver did not connect the power inflator to the buoyancy compensator and he inadvertently put his weight belt over the hose leading to the second stage of his regulator. The diver discovered these problems when he was already in the water and the strong current swept him away from his boat. The body was recovered the next day and the autopsy was consistent with drowning.

Drowning — Miscellaneous

DAN RECORD NO: 6995 **AGE:** 33 **SEX:** M **DIVER CAT:** T

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Seizure	780.3
Due to: Oxygen Toxicity	987.8
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): Y Findings available (Y/N): Y

A 33-year-old certified cave diver was making a complex, nitrox dive with an equally experienced dive buddy. The two divers entered a freshwater cave system and went to a maximum depth of 160 feet. The dive required using different breathing mixtures during various phases in order to minimize problems of narcosis, oxygen toxicity, and a prohibitive decompression obligation. After 60 minutes of bottom time, the divers decided to abort the rest of the dive due to poor visibility. During the ascent, the decedent had a seizure at 130 feet which was witnessed by his buddy. The body was recovered several hours later. An investigation revealed that the decedent inadvertently used his 50/50 nitrox mixture at a depth where the risk of central nervous system oxygen toxicity would be high. The medical examiner concluded that the cause of death was an air embolism, but this was based on minimal physical evidence. An isolated finding of gas in the heart and great vessels without any other evidence of air embolism or pulmonary barotrauma would be expected with the history of a long, deep dive. While a diver may suffer an air embolus during a seizure episode, this diver's seizure began while he was still deeper than 60 feet. The initial event in this fatal dive profile was most likely an oxygen-induced seizure.

DAN RECORD NO: 7795 **AGE:** 18 **SEX:** F **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Intracranial injury, open	854.1
Due to: Struck by power boat (jet ski)	E838.5
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): Y Findings available (Y/N): Y

An 18-year-old woman was diving with her husband in a lake. They headed for the surface when they both became low on air. Immediately upon reaching the surface, the woman was struck in the head by a jet ski. Resuscitation efforts at the scene were unsuccessful. The divers were not using a dive flag or marker buoy.

Death Due to Entrapment

These deaths resulted from a physical barrier that prevented a diver from returning to the surface. In some cases, the barrier was an overhead environment such as a cave or wreck. In other cases, the diver became entangled in kelp or a line. These hazards, despite being well-recognized, result in several deaths each year. The number of deaths that occurred during cave dives has increased during the past couple of years.

DAN RECORD NO: 1495 **AGE:** 35 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Entanglement (kelp)	E918
Due to: Recreational activity with diving equipment	E910.1

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

1: Left ventricular hypertrophy	429.3
2: Cannabinoid use	E980.3
3: Panic	308.0

Autopsy (Y/N): Y Findings available (Y/N): Y

A 35-year-old male who was a recently certified diver made his first night dive with two other divers. The divers became separated during ascent, and the decedent was found unconscious and tangled in kelp, approximately five feet from the bottom. Resuscitation efforts were unsuccessful. The findings at autopsy were consistent with drowning.

DAN RECORD NO: 2595 **AGE:** 45 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Entanglement (lines)	E918
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Coronary atherosclerosis	414.0
2: Left ventricular hypertrophy	429.3
3: Pulmonary emphysema, mild	492.8
4: Cannibinoid use	E980.3
Significant Incidental Diagnoses	
1: Fatty liver	571.8

Autopsy (Y/N): Y Findings available (Y/N): Y

A 45-year-old male certified diver with extensive diving experience made two dives on a wreck at 130 fsw. The first dive was uneventful, but during the second dive the decedent attempted to bring up a heavy souvenir using lift bags. The decedent became entangled in several lines while attempting to rig his lift bags, and he struggled to free himself. The decedent's buddy cut the lines to free the entangled diver, but not before the decedent became unconscious. After the unconscious diver was brought to the surface, resuscitation efforts were undertaken, but he was pronounced dead at a nearby hospital. The decedent's main tank was empty, but there was air left in his pony bottle. The autopsy findings were consistent with drowning.

DAN RECORD NO: 3895 **AGE:** 28 **SEX:** M **DIVER CAT:** R/T

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Entrapment (cavern)	E918
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): Y Findings available (Y/N): Y

A 28-year-old certified male diver was diving in a flooded cavern which was on private property behind a fence. Neither diver had received training in cave or cavern diving, and the bottom was composed of silt. Thirty minutes into the dive, the decedent and his buddy became separated. After surfacing, the dive buddy searched unsuccessfully for the diver who was found three hours later by a rescue team. The decedent was located in a dead-end branch of the cavern, and his air source had been exhausted.

DAN RECORD NO: 4995 **AGE:** 26 **SEX:** M **DIVER CAT:** R/T

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Entrapment (cave)	E918
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): Y Findings available (Y/N): Y

This 26-year-old male was the second of two divers who had open-water certification but no training in cave diving. They made a single dive in a freshwater cave system. When they did not return at the predetermined time, a search was initiated. The bodies were recovered several hours later, and both divers had run out of air. The autopsy on this diver was consistent with drowning.

DAN RECORD NO: 6895 **AGE:** 54 **SEX:** F **DIVER CAT:** R/T

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Entrapment (cave)	E918
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1
Significant Incidental Diagnoses	
1: Ovarian cysts	620.0

Autopsy (Y/N): Y Findings available (Y/N): Y

A 54-year-old woman who had open-water certification but no training in cave diving was in a group of nine divers, including the divemaster, who were exploring a complex underwater cave system. The divemaster was familiar with the cave but had no formal training for diving in caves. The first dive was uneventful, but during the second dive, all of the divers began to run low on air. The last diver in the group turned back and surfaced. Finally, after all of the divers became dangerously low on air, the divemaster surfaced and descended back down with a different tank. The divers had scattered and three divers, including the decedent mentioned here, were already unconscious. After all of the divers had exited or been removed from the cave, resuscitation efforts were attempted on three unconscious divers. This decedent and one other diver were pronounced dead at the scene. A third diver was later pronounced dead at a local hospital.

DAN RECORD NO: 8995 **AGE:** 30 **SEX:** M **DIVER CAT:** R/T

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Entrapment (cave)	E918
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): Y Findings available (Y/N): Y

Two divers with open-water certification but no training in cave diving made a single dive in a freshwater cave system. When they did not return at the predetermined time, a search was initiated. The bodies were recovered several hours later, and both divers had run out of air. This decedent was a 30-year-old male. The autopsy on this diver was consistent with drowning.

Autopsied Cases — Report Not Available

In general, DAN experiences excellent cooperation from medical examiners' offices and we receive timely reports on a majority of the diving fatalities. In every case, confidentiality regarding names and specific locations is maintained. There were 19 diving fatalities reported in 1995 where an autopsy was performed but the results were not made available to DAN. Several of these cases occurred outside of the United States, but the increasingly litigious environment surrounding fatal diving mishaps has resulted in less information being made available on U.S. fatalities as well.

Air Embolism

DAN RECORD NO: 795 **AGE:** 22 **SEX:** F **DIVER CAT:** U

Cause of Death	ICD-9-CM
Immediate: Arterial gas embolism	958.0
Due to: Rapid ascent	E902.2
Due to: Panic	308.0
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Nitrogen narcosis	293.0
2: Oxygen toxicity (probable)	987.8

Autopsy (Y/N): Y Findings available (Y/N): N

A 22-year-old uncertified woman was in a large group that had planned a dive to 300 fsw (using air) in an area where diving was restricted. She possibly suffered a seizure at a depth greater than 230 fsw and made a witnessed rapid ascent from that depth. The decedent was unconscious at the surface and was noted to have subcutaneous emphysema. Two other divers in the group were treated for decompression sickness. The findings of the postmortem examination are unavailable.

DAN RECORD NO: 6695 **AGE:** 49 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Arterial gas embolism	958.0
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): Y Findings available (Y/N): N

A 49-year-old diver with open-water certification but minimal diving experience made a seemingly uneventful dive to 110 fsw. While removing his equipment after the dive, the decedent rapidly became unconscious and could not be resuscitated. The diver had a history of a similar event from which he was resuscitated a few months earlier. The autopsy report is unavailable.

Cardiovascular Disease

DAN RECORD NO: 2195 **AGE:** 60 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Myocardial infarction	410.9
Due to: Coronary artery disease	414.9
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Insufficient air	E913.2
2: Coronary artery bypass graft	36.10
3: Tobacco abuse	305.1

Autopsy (Y/N): Y Findings available (Y/N): N

A 60-year-old certified diver was collecting scallops with two other divers. The other divers lost track of the decedent and then noticed him floating, face down, near shore. The cause of death was determined by a coroner prior to the completion of an autopsy. The coroner weighed the fact that the decedent had previous heart surgery very heavily in his investigation. The decedent's tank was empty and other causes of death, including drowning (with or without a myocardial infarction), cannot be ruled out. The findings of the autopsy are unavailable.

DAN RECORD NO: 2895 **AGE:** 51 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Cardiac dysrhythmia	427.9
Due to: Coronary atherosclerosis	414.0
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): Y Findings available (Y/N): N

A 51-year-old male certified diver was diving without a buddy when he suffered what was reported as a "heart attack." Apparently he was not feeling well earlier in the day and did not make the first dive with the rest of the group. Resuscitation efforts at the scene were unsuccessful, and the autopsy report is unavailable.

DAN RECORD NO: 10095 **AGE:** 51 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Cardiac dysrhythmia	427.9
Due to: Coronary atherosclerosis	414.0
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Recreational activity with diving equipment	E910.1
2: Obesity	278.0

Autopsy (Y/N): Y Findings available(Y/N): N

A 51-year-old male finished his second open water dive as a student in an initial certification class. He was reportedly overweighted and complained that his wetsuit was too tight. After ascending from his second dive, the decedent appeared to struggle on the surface and became unresponsive. He was found on the bottom with the regulator out of his mouth. Resuscitation efforts were unsuccessful and an independent, thorough investigation concluded that the cause of death was sudden cardiac arrest. An autopsy was performed but the results were unavailable.

Drowning With Medical Condition Present

DAN RECORD NO: 2395 **AGE:** 46 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Alcohol use, acute	305.0
2: Hypertension	401.9

Autopsy (Y/N): Y Findings available (Y/N): N

A 46-year-old male was in the water alone and using scuba equipment to collect mussels. His certification status and level of experience are unknown. The decedent was not wearing fins and did not have thermal protection despite diving in cold water (64 °F / 18 °C). A friend who waited for the decedent on shore went for help when the diver did not return at the expected time. A thorough search was initiated and the decedent was found in shallow water without his weight belt. The autopsy was reported to be consistent with drowning, but the report is unavailable for review.

Drowning Due to Insufficient Air

DAN RECORD NO: 1895 **AGE:** 23 **SEX:** F **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): Y Findings available (Y/N): N

A 23-year-old female certified diver was making her first night dive as part of a large group of divers. The dive included a shore entry in a freshwater lake with a planned dive to 80 feet. The rest of the group returned 30 minutes later and noticed that the decedent was missing. Her body was recovered eight hours later and an equipment check revealed an empty tank. The autopsy findings are not available.

DAN RECORD NO: 2995 **AGE:** 50 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): Y Findings available (Y/N): N

A 50-year-old male who was a novice certified diver made a 70-foot dive for 23 minutes. He ran out of air and needed to buddy breathe during the ascent. The decedent was unconscious on the surface and resuscitation efforts failed. The decedent was also noted to be overweighted. The autopsy report was not released.

DAN RECORD NO: 7695 **AGE:** 42 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): Y Findings available (Y/N): N

A 42-year-old experienced male diver entered the water with a group of divers to make a 30-minute dive to 80 fsw. When all members of the party returned to the boat except the decedent, one of the crew entered the water and found the decedent on the bottom and unconscious. Resuscitation efforts were unsuccessful. The coroner lists drowning due to an air embolus as the cause of death, but there is no basis in fact for this. The specifics of the autopsy findings were not made available.

DAN RECORD NO: 8895 **AGE:** 13 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): Y Findings available (Y/N): N

A 13-year-old male with junior diving certification made repetitive dives with three other divers. After completing the last dive, the decedent descended alone to retrieve the dive flag. He was the only one in the group with "significant" (400 psi) air remaining. The decedent's bubbles were seen to go past the dive flag and then disappeared. His body was recovered in 143 feet of water the next day. The autopsy report is unavailable.

Drowning / Accident

DAN RECORD NO: 3095 **AGE:** 41 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): Y Findings available (Y/N): N

A 41-year-old certified but inexperienced male diver entered the water alone to retrieve a fishing pole in 10 feet of water. Witnesses said that two minutes after the diver descended, his regulator, tank, and buoyancy compensator surfaced. Rescue divers found the decedent's body on the bottom two hours later. There was abundant structure on the bottom of this lake and it is possible that the decedent was attempting to free himself from an entrapment situation.

DAN RECORD NO: 5195 **AGE:** 52 **SEX:** M **DIVER CAT:** R
Cause of Death ICD-9-CM
Immediate: Drowning/nonfatal submersion 994.1
Due to: Recreational activity with diving equipment E910.1
Autopsy (Y/N): Y Findings available (Y/N): N
A 52-year-old male with open-water certification and limited diving experience became separated from his dive buddies just prior to ascent. The dive was to 46 fsw with an instructor and a student. The decedent was found on the bottom, unconscious and with his regulator out of his mouth. The tank contained over 1000 psi of air and there was reported to be blood in the decedent's mask. An autopsy report is not available.

DAN RECORD NO: 5995 **AGE:** 31 **SEX:** M **DIVER CAT:** R
Cause of Death ICD-9-CM
Immediate: Drowning/nonfatal submersion 994.1
Due to: Recreational activity with diving equipment E910.1
Autopsy (Y/N): Y Findings available (Y/N): N
This 31-year-old male was diving with two buddies when he decided to return to the boat because his air supply was low. The decedent's certification and experience level are unknown. He was not seen again until the body was recovered the next day. The autopsy was unavailable for review.

DAN RECORD NO: 7395 **AGE:** 43 **SEX:** F **DIVER CAT:** R
Cause of Death ICD-9-CM
Immediate: Drowning/nonfatal submersion 994.1
Due to: Recreational activity with diving equipment E910.1
Autopsy (Y/N): Y Findings available (Y/N): N
A 43-year-old female diver had a fair amount of diving experience, but she hadn't been diving in 18 months. The dive consisted of a shore entry in rough seas. As she entered the water, she complained that the neck dam was too tight on her dry suit. The decedent told her buddy that she was going to skip the dive, but when the other divers returned they found the decedent unconscious and floating beneath the surface. An independent investigation revealed that the dry suit could only inflate manually. The investigator determined that the neck dam was tight enough to interfere with breathing. The autopsy report was not released.

Death Due to Entrapment

DAN RECORD NO: 1795 **AGE:** 50 **SEX:** M **DIVER CAT:** R
Cause of Death ICD-9-CM
Immediate: Drowning/nonfatal submersion 994.1
Due to: Entanglement (kelp) E918
Due to: Recreational activity with diving equipment E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:
1: Panic 308.0
Autopsy (Y/N): Y Findings available (Y/N): N
A 50-year-old male student in an open-water course became entangled in kelp during the dive and panicked. His regulator came out of his mouth, but he refused assistance from an instructor. The diver was brought to the surface unconscious and resuscitative efforts were unsuccessful. The diver possibly had a history of heart disease with a pacemaker implanted, but details on this fatality are scarce and the autopsy report is not available.

DAN RECORD NO: 3495 **AGE:** 30 **SEX:** M **DIVER CAT:** R/T
Cause of Death ICD-9-CM
Immediate: Drowning/nonfatal submersion 994.1
Due to: Entrapment (cave) E918
Due to: Insufficient air E913.2
Due to: Recreational activity with diving equipment E910.1
Autopsy (Y/N): Y Findings available (Y/N): N
A 30-year-old male diver had significant diving experience, but no formal training in cave diving. He and his dive buddy entered a cave while collecting lobster. The two divers became separated when they stirred up silt and visibility became minimal. The decedent's buddy made it out of the cave and rescue divers recovered the decedent's body. His tank was empty. The autopsy report is unavailable.

DAN RECORD NO: 10395 **AGE:** 28 **SEX:** F **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Entrapment (water intake)	E918
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): Y Findings available (Y/N): N

A 28-year-old female certified diver entered the water to open a valve and allow a pond to drain. Three other workers were present, but the decedent was the only one who had scuba gear. After opening the valve she went back down to retrieve the wrench. The decedent was pulled into the pipe by the force of the exiting water and her coworkers were unable to extricate her from drain. No safety line or spare air source were present at the scene. The results of the autopsy findings are unavailable.

Death While Diving — Miscellaneous

DAN RECORD NO: 2795 **AGE:** 50 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Closed head injury	854.0
Due to: Struck by boat	E838.5
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): Y Findings available (Y/N): N

A 50-year-old male was diving alone when he was struck by a jet ski while on the surface. The accident was a hit and run incident, and it is unknown if the diver was using a flag or buoy. The diver's experience and certification level are unknown. The decedent's body was not recovered until the next day and his tank was noted to contain only 130 psi. The medical examiner determined the cause of death to be drowning, but the autopsy report was not available for review.

DAN RECORD NO: 7295 **AGE:** 49 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Intracranial injury, open	854.1
Due to: Struck by boat	E838.5
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): Y Findings available (Y/N): N

A very experienced 49-year-old male diver was ascending just as someone attempted to reposition the boat he was diving off of. The decedent was struck in the head by the propeller and pronounced dead at the scene. The autopsy report is unavailable.

Fatality Reports — Autopsy Not Performed

The complete investigation of a scuba diving fatality requires an autopsy. Scuba deaths may be considered sudden deaths because they are unexpected and occur within a short time of the causal event. The factors leading to a fatal outcome and manner of death are often clarified or confirmed by the findings at post-mortem examination.

Diving deaths cause tremendous psychological trauma to families and survivors. They may receive some solace, or an understanding of the event with full disclosure of the details of the accident or illness. It is very important to answer the family's questions fully, making it clear how and why the diver died.

There are legal reasons for autopsy. Frequently life insurance benefits are determined by the autopsy findings, such as the double indemnity provision in many policies for accidental death.

Scuba deaths are occasionally the basis for a lawsuit. Additionally, the victim is often young and otherwise healthy. The local medical examiner needs to keep the possibility of legal action in mind when deciding whether or not to order an autopsy. Reports should be written very carefully to avoid a suggestion of error by anyone when, in fact, none is known to exist.

Air Embolism

DAN RECORD NO: 1695 **AGE:** 32 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Anoxic encephalopathy	348.1
Due to: Arterial gas embolism	958.0
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): N Findings available (Y/N): N

A 32-year-old male with advanced open-water certification made two dives to greater than 100 fsw to explore a wreck. Both dives were decompression dives on air. At the end of the second dive, the decedent ran out of air and used his dive buddy's octopus. A third diver then ran out of air and panicked. All three divers ascended together using a shared air source. The ascent from 80 fsw was somewhat rapid, and the decedent was unconscious at the surface. He was treated in a hyperbaric chamber after initial stabilization but was pronounced brain dead after one treatment. The medical examiner did not order an autopsy.

DAN RECORD NO: 2095 **AGE:** 52 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Arterial gas embolism	958.0
Due to: Rapid ascent	E902.2
Due to: Insufficient air	E913.2
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): N Findings available (Y/N): N

A 52-year-old male certified diver was making his first dive of the day using enriched air (30 percent oxygen) to 115 fsw. After 38 minutes of bottom time, the decedent was witnessed to make an uncontrolled, rapid ascent from the bottom to approximately 25 fsw. Another diver witnessed the decedent having a seizure at 15 fsw and noticed that the decedent's depth gauge read 60 psi. The decedent wouldn't take the other diver's octopus, and the stricken diver was assisted to the surface. He was transported to a local hospital where he was pronounced dead. An autopsy was not performed.

Cardiovascular Disease

DAN RECORD NO: 4495 **AGE:** 50 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Cardiac dysrhythmia	427.9
Due to: Coronary atherosclerosis	414.0

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

1: Recreational activity with diving equipment	E910.1
2: Diabetes mellitus	250.0
3: Obesity	278.0

Autopsy (Y/N): N Findings available (Y/N): N/A

A 50-year-old male with multiple medical problems was making a night dive as part of his scuba certification course. He controlled his diabetes with oral medication and had been advised to have a treadmill test prior to beginning his dive training, but he refused. The decedent had minimal diving experience, but it was reported that this dive was part of an advanced open-water course. After two uneventful dives, the decedent surfaced early during the third dive and complained of difficulty with breathing. He quickly became unconscious and resuscitation efforts were unsuccessful. The medical examiner did not feel an autopsy needed to be performed in this case.

DAN RECORD NO: 4595 **AGE:** 38 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Myocardial infarction	410.9
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): N Findings available: N

A 38-year-old male with advanced open-water certification was making a series of dives in a lake using a shore entry. The diver reportedly had a history of hypothyroidism and prior to the first dive he experienced chest pain which he attributed to indigestion. The first dive lasted only 10 minutes, and the diver was so fatigued that he required assistance with his gear.

During the surface swim of the second dive, the decedent was noticeably struggling and then became unconscious. The decedent was brought to shore and transferred to a hospital where he died the next day. An autopsy was not performed.

DAN RECORD NO: 10295 **AGE:** 51 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Myocardial infarction	410.9
Due to: Coronary atherosclerosis	414.0
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: History of cardiac dysrhythmia	427.9
2: Obesity	278.0
3: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): N Findings available (Y/N): N

A 51-year-old, inexperienced but certified, male diver made a dive to 65 fsw for 15 minutes to explore a wreck. After ascending, the decedent complained of having trouble breathing on the surface. He became unconscious, was resuscitated and transferred to a local intensive care unit. The diver died the next day from complications of a myocardial infarction. An autopsy was not performed.

Drowning Due to Insufficient Air

DAN RECORD NO: 4895 **AGE:** 47 **SEX:** M **DIVER CAT:** T

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Insufficient air	E913.2
Due to: Entrapment (cave)	E918
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): N Findings available (Y/N): N

A 47-year-old male certified cave diver was exploring a complex cave system with an equally experienced and qualified dive buddy (case 5895). The two divers made several navigational errors and missed a turn which would have led them to the exit. Their bodies were recovered by a search team several hours later. No autosy was performed, but both divers were out of air.

Drowning / Accident

DAN RECORD NO: 6795 **AGE:** 14 **SEX:** F **DIVER CAT:** U

Cause of Death	ICD-9-CM
Immediate: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1. Panic	308.0

Autopsy (Y/N): N Findings available (Y/N): N

A 14-year-old female was trying out diving equipment which belonged to a certified diver who accompanied the decedent into the water. The decedent had no previous experience with diving, and her partner was a certified diver but not an instructor. The two divers entered a freshwater spring and planned to stay in shallow water. The decedent began to slip down an embankment and headed out into the river. She lost her regulator and would not accept the octopus from her dive buddy. The decedent was brought to shore unconscious and died in a hospital the next day. No autopsy was performed.

DAN RECORD NO: 8095 **AGE:** 24 **SEX:** F **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Anoxic encephalopathy	348.1
Due to: Drowning/nonfatal submersion	994.1
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Panic	308.0

Autopsy (Y/N): N Findings available (Y/N): N

A 24-year-old certified diver with little diving experience planned to dive in a quarry which had a maximum depth of 53 feet. She was noticed to be quite anxious during the predive period. The diver panicked at 25 feet and took her regulator out of her mouth. The decedent's dive buddy surfaced to get assistance and returned to find the diver unconscious and on the bottom.

The decedent was resuscitated at the scene and spent four weeks in an intensive care unit before she was pronounced brain dead. An autopsy was not performed.

DAN RECORD NO: 8695 **AGE:** 38 **SEX:** F **DIVER CAT:** R
Cause of Death ICD-9-CM
Immediate: Anoxic encephalopathy 348.1
Due to: Drowning/nonfatal submersion 994.1
Due to: Recreational activity with diving equipment E910.1
Autopsy (Y/N): N Findings available (Y/N): N
A 38-year-old female was a student in an initial open-water certification course. She was making one of the required open-water dives in cold water where the visibility was poor. The student experienced difficulty equalizing pressure in her ears during descent and returned to the surface with one of the instructors. She then attempted to descend again in order to join the other students. The decedent was not with the group at the end of the dive and a search of the area found her on the bottom without a regulator in her mouth. She was kept on life support for four days before being pronounced dead. An autopsy was not performed and the equipment was found to be in good working condition.

DAN RECORD NO: 9595 **AGE:** 35 **SEX:** M **DIVER CAT:** R
Cause of Death ICD-9-CM
Immediate: Drowning 994.1
Due to: Recreational activity with diving equipment E910.1
Autopsy (Y/N): N Findings available (Y/N): N
A 35-year-old male was a certified but an inexperienced diver who entered the water alone according to witnesses. He was later seen struggling on the surface then submerged again. Police divers recovered the body from the bottom. According to the medical examiner, an autopsy was not performed because foul play was not suspected.

Death Due to Entrapment

DAN RECORD NO: 4395 **AGE:** 37 **SEX:** M **DIVER CAT:** R/T
Cause of Death ICD-9-CM
Immediate: Drowning/nonfatal submersion 994.1
Due to: Entrapment (cave) E918
Due to: Insufficient air E913.2
Due to: Recreational activity with diving equipment E910.1
Autopsy (Y/N): Y Findings available (Y/N): N
A 37-year-old male certified diver was making a dive in a lake with two buddies. None had formal training in cave diving. The divers inadvertently entered a cave, and the visibility was poor due to stirred up silt. They became separated and only two of the divers made it out of the cave. The decedent's body was recovered seven hours later, approximately 200 yards into the cave. His air source had been exhausted. An autopsy was not performed.

DAN RECORD NO: 5895 **AGE:** 37 **SEX:** M **DIVER CAT:** T
Cause of Death ICD-9-CM
Immediate: Drowning/nonfatal submersion 994.1
Due to: Entrapment (cave) E918
Due to: Insufficient air E913.2
Due to: Recreational activity with diving equipment E910.1
Autopsy (Y/N): N Findings available (Y/N): N
This was the dive partner of the other certified cave diver (case 4895) who died while exploring a complex cave system. He was 37 years old and a certified cave diver.

Bodies Not Recovered

Each year there are cases where diving fatalities occur but a body is not recovered. There were nine such cases in 1995. In a few instances, the circumstances surrounding the mishap are known but most often the final events of the dive are not known.

DAN RECORD NO: 395 **AGE:** 27 **SEX:** M **DIVER CAT:** R/T

Cause of Death	ICD-9-CM
Immediate: Unknown cause of death (body not recovered)	799.9
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Nitrogen narcosis	293.0

Autopsy (Y/N): N Findings available (Y/N): N

A 27-year-old experienced diver was training to set a world depth record for air using scuba. He had made several dives in excess of 350 fsw prior to this dive and his goal was 550 fsw. This dive was planned to go to greater than 450 fsw using a descent line and decompression on oxygen but no safety divers. After 20 minutes a line pull signal was felt to have been returned, but the diver was never heard from after that. A body was never recovered.

DAN RECORD NO: 495 **AGE:** 21 **SEX:** F **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Unknown cause of death (body not recovered)	799.9
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Nitrogen narcosis (possible)	293.0

Autopsy (Y/N): N Findings available (Y/N): N

A 21-year-old certified female diver with approximately 15 lifetime dives was caught up in a strong current and swift tide which caused her to become separated from her buddy. At one point the current pulled the dive buddy, and likely the decedent, from 80 fsw down to 153 fsw. The dive buddy was treated in a recompression chamber, and the decedent's body was never recovered.

DAN RECORD NO: 2495 **AGE:** 31 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Unknown cause of death (body not recovered)	799.9
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): N Findings available (Y/N): N

A 31-year-old male dive instructor was making multiple dives on a wall with two other divers. On the third dive of the day, the decedent descended ahead of his two dive buddies and continued down the wall. He was not seen again and the body was never recovered.

DAN RECORD NO: 3995 **AGE:** 42 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Unknown cause of death (body not recovered)	799.9
Due to: Recreational activity with diving equipment	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
1: Insufficient air	E913.2

Autopsy (Y/N): N Findings Available (Y/N): N

A 42-year-old male dive instructor was spearfishing on a wall using a drysuit and scuba gear. He made three dives, all to greater than 100 fsw, with the first two dives being rather uneventful. During the third dive, the decedent became low on air and showed his gauge to his dive buddy before heading to the surface. The dive buddy followed, but he lost sight of the decedent at the decompression stop. The decedent's body was never recovered.

DAN RECORD NO: 4695 **AGE:** 28 **SEX:** M **DIVER CAT:** R

Cause of Death	ICD-9-CM
Immediate: Unknown cause of death (body not recovered)	799.9
Due to: Recreational activity with diving equipment	E910.1

Autopsy (Y/N): N Findings available (Y/N): N

A 28-year-old male certified, experienced diver was diving with a buddy in an attempt to find a reef. The predive plan called for a maximum depth of 80 fsw, but the decedent continued to descend. At 135 fsw the decedent's buddy had difficulty equalizing pressure in his ears and let the decedent continue on alone. The body was not recovered.

DAN RECORD NO: 5395 **AGE:** 30 **SEX:** M **DIVER CAT:** R
Cause of Death ICD-9-CM
Immediate: Unknown cause of death (body not recovered) 799.9
Due to: Recreational activity with diving equipment E910.1
Autopsy (Y/N): N Findings available (Y/N): N
A 30-year-old dive instructor went over the edge of a wall and became separated from the group of divers. He descended deeper than 100 fsw and was not seen again. A search for the diver's body was unsuccessful.

DAN RECORD NO: 5795 **AGE:** 53 **SEX:** F **DIVER CAT:** R
Cause of Death ICD-9-CM
Immediate: Unknown cause of death (body not recovered) 799.9
Due to: Recreational activity with diving equipment E910.1
Autopsy (Y/N): N Findings available (Y/N): N
A 53-year-old certified female diver with minimal experience became separated from her dive buddy. It was known that she had been feeling ill for a week prior to the dive, and she may have had a history of a heart problem. The body was never recovered.

DAN RECORD NO: 6295 **AGE:** 36 **SEX:** M **DIVER CAT:** R/T
Cause of Death ICD-9-CM
Immediate: Unknown cause of death (body not recovered) 799.9
Due to: Recreational activity with diving equipment E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:
1: Nitrogen narcosis 293.0
Autopsy (Y/N): N Findings available (Y/N): N
A 36-year-old male certified diver was making his first dive in eight years on a wall with another diver and an instructor. At 140 fsw the decedent experienced difficulty and was assisted by the buddy and the instructor up to 40 fsw. The other divers ascended to the boat and assumed that the decedent was doing the same. When the decedent did not surface, a search was initiated, but the body was never recovered.

DAN RECORD NO: 10195 **AGE:** 47 **SEX:** M **DIVER CAT:** R
Cause of Death ICD-9-CM
Immediate: Unknown cause of death (body not recovered) 799.9
Due to: Recreational activity with diving equipment E910.1
Autopsy (Y/N): N Findings available (Y/N): N
A 47-year-old certified diver with minimal diving experience was on a live-aboard dive trip. Ten minutes into a 130-foot dive he communicated to other divers that he felt ill and then made a rapid, controlled ascent. Witnesses stated that he then quickly submerged after reaching the surface and was not seen again. The diver's equipment was recovered, but no body was ever found. It certainly is possible that nitrogen narcosis and/or air embolus figure into this fatal diving scenario.

Unknown Cause of Death

In these cases not enough information was available to even speculate about the cause of death. Many of these cases involved U.S. citizens diving abroad and the details of their death, if in fact it actually occurred in the water, were unknown.

DAN RECORD NO: 6595 **AGE:** 53 **SEX:** M **DIVER CAT:** R
Cause of Death ICD-9-CM
Immediate: Unknown cause of death 799.9
Due to: Recreational activity with diving equipment E910.1
Autopsy (Y/N): N Findings available (Y/N): N
A 53-year-old male had a fatal diving mishap during his second dive of the day. No further information is available on this case.

DAN RECORD NO: 7095 **AGE:** 219 **SEX:** F **DIVER CAT:** R
Cause of Death ICD-9-CM
Immediate: Unknown cause of death 799.9
Due to: Recreational activity with diving equipment E910.1
Autopsy (Y/N): N Findings available (Y/N): N
Little information is available on the death of this 19-year-old female certified diver. She had made multiple dives and possibly suffered some kind of trauma.

DAN RECORD NO: 8595 **AGE:** 42 **SEX:** M **DIVER CAT:** R
Cause of Death ICD-9-CM
Immediate: Unknown cause of death 799.9
Due to: Recreational activity with diving equipment E910.1
Autopsy (Y/N): N Findings available (Y/N): N
No other information is available on this 42-year-old male who was reported as a recreational diving fatality.

DAN RECORD NO: 9495 **AGE:** 49 **SEX:** M **DIVER CAT:** R
Cause of Death ICD-9-CM
Immediate: Unknown cause of death 799.9
Due to: Recreational activity with diving equipment E910.1
Autopsy (Y/N): N Findings available (Y/N): N
Very little information is known about the death of this 49-year-old male diver. He was part of a large group diving from a charter boat.

Summary

These fatality case reports are presented here to use as an instructional device for all divers, from novice to seasoned veteran. Nearly every report has a take home message or lesson learned that hopefully will prevent future similar outcomes. A majority, though not all, of these fatality cases involve an error in judgment or a violation of accepted safe diving practices. As divers, we are responsible for our own actions and must ensure that we are:

- adequately trained for the type of dive planned, including advanced training for more challenging types of diving
- mentally and physically prepared to dive with enough reserve to handle changing dive conditions and emergencies
- well acquainted with our dive equipment and that the equipment is kept in proper working order

Most diving fatalities are accidents that are preventable. Important contributing factors to a fatal diving mishap include pre-existing health problems, level of physical fitness, and the influence of alcohol or other drugs. Conservative diving habits for novice divers should be encouraged and advanced training prior to engaging in more challenging types of diving is essential.

Notes

1. International Classification of Diseases, 9th Revision, Clinical Modification, fourth edition, U.S. Department of Health and Human Services, Health Care Financing Administration.
2. Kindwall, EP and Pellegrini, JP. Autopsy Protocol for Victims of Scuba Diving Accidents, *1992 Report on Diving Accidents and Fatalities*, Divers Alert Network: Durham, NC, 1994.
3. Di Maio, DJ and Di Maio, VJ. *Forensic Pathology*, CRC Press: Boca Raton, 1993
4. National Center for Health Statistics, U.S. Public Health Service, DHHS.
5. Caruso, JL, et al. Recreational Diving Fatalities in the United States, 1990-1994: Patterns and Trends. Undersea and Hyperbaric Medicine, 23(supp):60-61, 1996.
6. Dovenbarger, JD, ed. *1993 Report on Diving Accidents and Fatalities*, Divers Alert Network: Durham, NC, 1995, p. 34.

The views expressed in this article are those of the author and do not reflect the official policy or position of the Department of the Navy, Department of Defense, or the U.S. Government.

Appendix B

Autopsy Protocol for Recreational Scuba Diving Fatalities

The *1992 Report on Diving Accidents and Fatalities* included an autopsy protocol written by Drs. Eric Kindwall and Jorge Pellegrini (1). Several aspects of that protocol have been incorporated in the following section on performing and interpreting a postmortem examination on a diving fatality victim.

Since most pathologists and autopsy technicians rarely perform an autopsy on someone who died while scuba diving, few medical examiners' offices will have significant experience in performing appropriate postmortem examinations in that setting. The following is a guideline which can be followed with the understanding that some of the recommended procedures will be impractical and may only take place in a facility with significant laboratory resources available.

The medical examiner must put together all of the available information, including the autopsy findings, prior to determining the cause of death in a diving fatality. If the pathologist performing the autopsy is unfamiliar with diving physiology, consultation should be obtained to assist in the interpretation of the findings.

History

This is absolutely the most important part of the evaluation of a recreational diving fatality. Ideally, one should obtain significant past medical history with a focus especially on cardiovascular disease, seizure disorder, diabetes, asthma, and chronic obstructive pulmonary disease. Medications taken on a regular basis as well as on the day of the dive should be recorded and information regarding how the diver felt prior to the dive should be obtained. Any history of drug or alcohol use must also be noted. The dive history is extremely important. If possible, the investigator should find out the diver's experience and certification level. The most important part of the history will be the specific events related to the dive itself. The dive profile (depth, bottom time) is an essential piece of information and if the diver was not diving alone (they are taught never to do so), eyewitness accounts will be invaluable. Questions to be asked include:

- When did the diver begin to have a problem (predive, descent, bottom, ascent, postdive)?
- Did the diver ascend rapidly (a factor in air embolism and pulmonary barotrauma)?
- Was there a history of entrapment, entanglement, or physical trauma?
- If resuscitation was attempted, what was done and how did the diver respond?

External Examination and Preparation

- A thorough external examination including a search for signs of trauma, animal bites, or envenomation should be carried out. Palpate the area between the clavicles and the angles of the jaw for evidence of subcutaneous emphysema. X-rays of the head, neck, thorax, and abdomen should be taken to look for free air.
- Modify the initial incision over the chest to make a "tent" out of the soft tissue (an "I" shaped incision) and fill this area with water. A large bore needle can be inserted into the second intercostal spaces bilaterally; if desired, any escaping air can be captured in an inverted, water filled, graduated cylinder for measurement and analysis. As the breastplate is removed, note any gas escaping from vessels. Excellent diagrams in one of the standard forensic pathology texts (2).
- Open the pericardial sac under water and note if pneumopericardium is present. Repeat the needle insertion maneuver, this time into the right and left ventricles with capture of any escaping gas if practical. After the mediastinum, heart, and great vessels have been examined under water for the presence of air, the water may be evacuated and a standard autopsy may be performed.
- Carefully examine the lungs for bullae, emphysematous blebs, and hemorrhage.

- Note any inter-atrial or inter-ventricular septal defects. Carefully check for evidence of cardiovascular disease and any changes that would compromise cardiac function.
- Toxicology-obtain blood, urine, vitreous, bile, liver, and stomach contents. Not all specimens need to be analyzed, but at least look for drugs of abuse. If an electrolyte abnormality is suspected or if the decedent is a diabetic, the vitreous may prove useful.
- Prior to opening the skull, tie off all of the vessels in the neck to prevent artifactual air from entering the intracranial vessels. Tie the vessels at the base of the brain once the scull is opened. Disregard bubbles in the superficial veins or venous sinuses. Examine the meningeal vessels and the superficial cortical vessels for the presence of gas. Carefully examine the circle of Willis and middle cerebral arteries for bubbles.
- Have an expert evaluate the dive gear. Are the tanks empty? If not, the gas should analyzed for purity (a little carbon monoxide goes a long way at depth). All gear should be in good working order with accurate functioning gauges.

Possible Findings

The following anatomic findings may be seen with the clinical entities listed. Not all of the anatomic changes will be seen in each case and the lists are certainly not exhaustive.

- **air embolism**: intra-arterial and intra-arteriolar air bubbles in the brain and meningeal vessels, petechial hemorrhages in gray and white matter, evidence of COPD or pulmonary barotrauma (pneumothorax, pneumomediastinum, subcutaneous emphysema), signs of acute right heart failure, pneumopericardium, air in coronary and retinal arteries.
- **decompression sickness**: lesions in the white matter in the middle third of the spinal cord including stasis infarction; if there is a patent foramen ovale (or other potential right-to-left heart shunt) a paradoxical air embolism can occur due to significant venous bubbles entering the arterial circulation.
- **venomous stings or bites**: a bite or sting on any part of the body, unexplained edema on any part of the body, evidence of anaphylaxis or other severe allergic reaction.

Interpretation

- The presence of gas in any organ or vessel after a scuba diving death is not conclusive evidence of decompression sickness or air embolism. During a long dive inert gas dissolves in the tissues and the gas will come out of solution when the body returns to atmospheric pressure. This, combined with postmortem gas production, will produce bubbles in tissue and vessels. This has caused many experienced pathologists to erroneously conclude that a death occurred due to decompression sickness or air embolism.
- Intravascular bubbles, especially if present predominantly in arteries, found during an autopsy performed soon after the death occurred is highly suspicious for air embolism. The dive history will help support or refute this theory.
- Gas present only in the left ventricle or if analysis shows the gas in the left ventricle has a higher oxygen content than that present on the right side would lead the pathologist to correctly conclude that an air embolism probably occurred.
- Intravascular gas from decomposition or off-gassing from the dive would have little oxygen and be made up of mostly nitrogen and carbon dioxide.
- Deeper, longer dives can cause decompression sickness and significant intravascular (mostly venous) gas. Rapid ascents and pulmonary barotrauma are associated with air embolism.

The Divers Alert Network has medical personnel who are available to provide guidance in the performance and interpretation of autopsies on diving accident victims.

1. Kindwall, EP and Pellegrini, JP. Autopsy Protocol for Victims of Scuba Diving Accidents, *1992 Report on Diving Accidents and Fatalities*, Divers Alert Network: Durham, NC, 1994.

2. Spitz, WV (editor). Medicolegal Investigation of Death. pp 776-778. Charles C. Thomas: Springfield, IL, 1993.

Appendix C

Fatality Location Tables

U.S. Fatalities from 1970 to 1995 in Foreign Areas

Country	80-89	90-92	1993	1994	1995	Totals
Anguilla	1					1
Antigua	1					1
Australia	2			1		3
Bahamas	19	6	1	7	6	39
Barbados	2					2
Bequia		1				1
Bermuda	1	1				2
Belize	4	1				5
British Virgin Islands	4			1		5
Canada	6	1				7
Caribbean Area		2				2
Cayman Islands	5	2	2	3	1	13
Costa Rica	1					1
Dominica		1				1
Egypt		1				1
Fiji Islands	2				1	3
French Antilles	2					2
Greece	1					1
Honduras	2	1	1	1		5
Italy		2				2
Jamaica		3				3
Japan	3	2		1		6
Malaysia	1					1
Martinique	1	1				2
Mexico	28	15	6	2	5	56
Micronesia		1				1
Morocco	1					1
Netherlands Antilles - Saba, Aruba, Bonaire, Curacao	2	2	1	3	1	9
New Caledonia	1					1
Palau		1				1
Panama		1				1
Phillipines	2					2
Portugal	1					1
Red Sea	3					3
St. Marteen					1	1
St. Martin		1				1
St Vincent/Grenadines	4					4
Saipan	1	1				2
Tahiti			1	1		2
Thailand	1					1
Saudi Arabia	2					2
Unknown	1					1
Totals	**105**	**47**	**12**	**20**	**15**	**199**

Fatality Location Tables

U.S. Fatalities from 1970 to 1995 by State

State	80-89	90-92	1993	1994	1995	Totals
Alabama	2	1		2		5
Alaska	9	2		1		12
Arizona	4			1		5
Arkansas	8	1		1	4	14
California	155	39	15	11	14	234
Colorado						
Connecticut	9	1			2	12
Delaware	3	1	1			5
Florida	231	58	27	25	22	363
Georgia	11	1		1		13
Hawaii	54	8	7	1	3	73
Idaho	4					4
Illinois	3	1			1	5
Indiana	1	1			1	3
Iowa		2				2
Kansas						
Kentucky	1					1
Louisiana	5	3	1		2	11
Maine	8	5		1		14
Maryland	1			1		2
Massachusetts	32	5	3	4	5	49
Michigan	12	2	2	2	2	20
Minnesota	4	1			1	6
Mississippi	3			1		4
Missouri	3	5				8
Montana	2	1				3
Nebraska	5					5
Nevada	2	1	1		1	5
New Hampshire	4					4
New Jersey	15	11	1	3	2	32
New Mexico	4	2		1	1	8
New York	21	10	3	2	2	38
North Carolina	12	3			2	17
Ohio	6	2		1		9
Oklahoma	1		1			2
Oregon	11	2	3			16
Pennsylvania	7	10	1	2	2	22
Rhode Island	19	4			2	25
South Carolina	3		1	1		5
South Dakota		1				1
Tennessee	4	2			1	7
Texas	19	4	2	1	2	28
Utah	5	1			1	7
Vermont	1					1
Virginia	5		1	1		7
Washington	67	8	2	6	10	93
West Virginia		1		1	1	3
Wisconsin	10	3	2	1	2	18
Wyoming	2					2
Washington DC						
Totals	**788**	**203**	**74**	**72**	**86**	**1223**

Fatality Location Tables

U.S. Fatalities from 1970 to 1995 by U.S. Territory

U.S. Territory	80-89	90-92	1993	1994	1995	Territory Totals
Guam				3	2	4
Marshall Island				2		3
Puerto Rico	5	1				10
Virgin Islands	11	3	6	2	1	23
Totals	**16**	**4**	**6**	**7**	**3**	**36**

To report an injury, a fatality, or a near-miss in diving, call the DAN Medical Department.

Divers Alert Network
3100 Tower Boulevard · Suite 1300
Durham, NC 27707
(919) 684-2948

Appendix D

ICD-9-CM Codes for Dive-Related Incidents

36.05	Angioplasty
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
185	Malignant neoplasm — prostate
189.0	Renal cell carcinoma
245.1	Chronic thyroiditis
245.2	Chronic lymphocytic thyroiditis
250.0	Diabetes mellitus
250.4	Diabetes mellitus with glomerulosclerosis
278.0	Obesity, exogenous
293.0	(Nitrogen narcosis)
	acute delirium
293.0	Acute confusional state
298.0	Reactive depressive psychosis
303.0	Ethanol dependence syndrome
.0	unspecified
.1	continuous
.2	episodic
.3	in remission
305	non-dependent drug abuse
305.0	Alcohol abuse (acute)
305.1	Tobacco abuse
308.0	Panic state
	Acute stress reaction, emotional
336.1	Intraparenchymal hemorrhage of spinal cord
345.9	Epilepsy NOS without intractable epilepsy
347	Cataplexy and narcolepsy
348.1	Anoxic brain damage
	Anoxic encephalopathy
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 with renal involvement
410.6	True posterior wall infarction
410.9	Acute myocardial infarction
414.0	Coronary atherosclerosis
414.9	Coronary artery disease
425.4	Hypertrophic cardiomyopathy
	Primary cardiomyopathy
427.41	Ventricular fibrillation
427.9	Cardiac dysrhythmia (unspecified)
428.0	Congestive heart failure
428.1	Left heart failure (pulmonary edema)
429.1	Myocardial degeneration
429.2	Arteriosclerotic cardiovascular disease (ASCVD)
429.3	Ventricular hypertrophy (cardiomegaly)
436	Cerebrovascular accident (CVA)
437	Cerebral aneurysm
440	Atherosclerosis aorta
466.0	Acute bronchitis
490	Bronchitis NOS
492.0	Emphysematous blebs
492.8	Pulmonary emphysema
493.9	Asthma (unspecified)
496	Chronic obstructive lung disease
508.9	Pulmonary edema due to external agent
512.0	Spontaneous pneumothorax
518.1	Pneumomediastinum
	Interstitial emphysema, mediastinal emphysema
518.5	Acute respiratory distress syndrome (ARDS)
	Post traumatic pulmonary insufficiency
518.8	Other pulmonary insufficiency
531.9	Stomach ulcer NOS
571.2	Cirrhosis of liver (alcoholic)
571.8	Fatty liver
	Chronic nonalcoholic liver disease
584.5	Lower nephron nephrosis
	Acute tubular necrosis
745.5	Secundum type atrial septal defect
	Patent foramen ovale
753.1	Cystic kidney disease
780.0	Coma
780.3	Seizure disorder
782.3	Pulmonary edema
786.09	Respiratory insufficiency, distress, wheezing
786.3	Pulmonary hemorrhage
789.1	Hepatomegaly
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.)
799.0	Asphyxia (hypoxemia d/t exertion)
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

ICD-9-CM Codes for Dive-Related Incidents — Continued

958.7 Subcutaneous emphysema
980.0 Ethanol, toxic effect
986 Carbon monoxide poisoning (see E codes)
987.8 Oxygen toxicity
993 Barotrauma
993.0 Barotrauma, otitic
993.1 Barotrauma, sinus
993.3 Decompression sickness
994.1 Drowning and non-fatal submersion
994.5 Exhaustion due to excess exertion
994.8 Effects of electric current
E830 Rowboat drown accident, occupant
E830.1 Powerboat drowning accident, occupant
E838.5 Struck by boat
E902.2 Rapid ascent
E906.3 Shark bites
E910.1 Accident d/t water sports activity
Recreational activity with diving equipment
E910.3 Diving for purposes other than recreation with diving equipment
Marine salvage, rescue, construction, etc.
E913.2 Insufficient air
Accidental suffocation, lack of 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

* DAN adaptation of code

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
E941.2 Pseudoephedrine
E980.3 Cannabinoids
E980.3 Methamphetamine
E980.4 Cocaine

Toxicology

Volatiles — ethanol, methanol, acetone, isopropanol and toluene.

Amphetamines — includes amphetamine, methamphetamine, phenylpropanolamine, MDA, ephedrine, pseudoephedrine and related compounds.

Barbiturates and Sedatives — includes phenobarbital, diazepam, chlordiazepoxide, flurazepam, alprazolam, triazolam, oxazepam and metabolites.

Opiates — includes heroin metabolites, morphine, codeine, meperidine, hydromorphone, hydrocodone and related compounds.

Cyclic antidepressants — includes amitriptyline, nortriptyline, imipramine, desipramine, doxepin, chlorpromazine and other related compounds such as cyclobenzaprine, thioridazine and structurally related compounds.

Antihistamines — includes diphenhydramine, tripelennamine, chlorpheniramine, and other related compounds.

Psychotropics — includes phenothiazines, cyclic anti-depressants, antianxiety agents and other related compounds.

Organic bases — includes pentazocine, methaqualone, cocaine and metabolites, propoxyphene, strychine, methadone, ethclorvynol, quine, chlorinated hydrocarbons and other related compounds.

Abbreviations

d/t	due to
s/p	status post
w/o	without
ALS	Advanced life support
ARDS	Adult respiratory distress syndrome
ATN	Acute tubular necrosis
CAD	Coronary artery disease
CABG	Coronary artery bypass graft
LAD	Left anterior descending coronary artery
Lcirc	Circumflex coronary artery
NOS	Not otherwise specified
NEC	Not elsewhere classifiable
RCA	Right coronary artery

Appendix E

Nitrox and Mixed-Gas Diving

Joel Dovenbarger, BSN, Director of Medical Services

There have been many advances in recreational diving since the first national training program was instituted by the YMCA in 1959. Almost everything about recreational diving and diving equipment has evolved to a newer and higher form. Even the recommended safety guidelines for recreational diving have been modified over the years to reflect current understanding and knowledge of safe diving practices. Innovations in the operation of scuba regulators, buoyancy compensators, weighting systems, and the design of masks, fins and exposure suits (i.e., wet- and drysuits) have all added to the ease, comfort and sometimes the safety of diving. The introduction of decompression computers revolutionized the way divers were able to calculate and follow decompression procedures for recreational diving.

Today, the newest and perhaps most controversial addition to scuba for the general recreational scuba diving public is the use of gas mixtures other than compressed air, such as nitrox or mixed gas. Nitrox is a mixture of oxygen and nitrogen other than air. Mixed gas refers to a breathing mix containing an inert gas other than nitrogen or a mix where another inert gas (such as helium) has been added to a nitrox or air mix. Of the two, nitrox diving is performed much more than mixed-gas diving. Both are controversial, because prior to recent years, mixed gas was used solely in commercial and government diving, and more recently in scientific dive operations. This implied that nitrox or mixed-gas diving was far too complex and required much more training than the average recreational diver might receive. All that changed in 1985, when Dick Rutkowski began the International Association of Nitrox and Technical Divers (IANTD) and began instructing recreational divers in the use of nitrox. The instructional course followed the policies and procedures developed by the National Oceanic Atmospheric Administration (NOAA) for nitrox diving. By the end of 1995, the collection year this data is based on, there were a total of 11 nitrox or mixed-gas certifying agencies in North America.

The growing popularity of nitrox and mixed-gas diving has encouraged DAN to produce a brief analysis of the limited data available on recreational mixed-gas diving. In previous years there were not enough cases to warrant spending the time necessary to collect and follow up on mixed-gas diving injuries. Between 1990 and 1992 DAN received only seven cases. In 1993, 14 cases were received and in 1994, 10 cases were sent in to DAN. Some of these cases were not in certified mixed-gas divers and were using "home-brew" mixtures. The 1995 data is based on a small group of 16 certified mixed-gas cases that were treated in hyperbaric chambers. In all, only 48 cases have been reported to DAN in the last five years. Additionally, in the past three years there have been five recreational deaths where the divers were using mixed gas. Three deaths occurred in 1995, two in 1994, and no deaths occurred in 1993 using mixed gas. These cases are included in the accident scenario appendix of the annual reports.

Since DAN does not receive an accident form on every treated case it is more than likely these 16 cases do not represent the total number of injuries among divers using nitrox or mixed gas. DAN received 21 emergency calls from mixed-gas divers in 1995, 10 of which were treated for decompression sickness. Five of those 10 cases are included in the report. The remaining five did not have forms sent in by the treatment facility. An additional five callers had DCS symptoms post-dive but declined evaluation. The remaining six callers were diagnosed with dermatitis, abdominal pain, muscle strain, pulmonary barotrauma, middle ear barotrauma and cerebral vessel rupture.

There is no way of determining incidence results. This is because there is no way of knowing how many mixed-gas or nitrox divers participate in diving each year and how many dives are performed. For example, IANTD reports certifying approximately 10,006 U.S. nitrox divers since 1985, but it is

impossible to determine how many are still active in nitrox and mixed-gas diving. The reported cases in this database are also not well distributed, with 12 of the 16 cases (75 percent) occurring in Florida. One case each was reported in Hawaii, New Jersey and Wisconsin, and there was one case in Mexico. A second case in Mexico was removed from the database when the diver couldn't remember whether he used mixed gas.

Diver Characteristics

There is little to differentiate a recreational air diver from a recreational nitrox or mixed-gas diver. By in large, they use similar equipment. They do differ in the amount of specialized training they receive and in operational procedures they are required to follow when using oxygen-enriched diving mixtures. Nitrox and mixed-gas divers should also be well informed about the potential for oxygen toxicity, a risk rarely encountered in air diving. The gas mix used by the small population of fatalities was primarily nitrox (32 and 36 percent oxygen). There were three divers who used a nitrox mix with oxygen concentrations of greater than 40 percent oxygen; two divers used trimix (a mixture of oxygen, nitrogen and helium) gas with 16 and 20 percent oxygen, respectively, with the balance as helium and nitrogen; and at least one diver used nitrox only for the staged decompression gas.

It is difficult to draw any conclusions about nitrox and mixed-gas divers because of the small number of cases and the limited data. Characteristics of air divers can, however, be compared to those of nitrox or mixed-gas divers. The age range is roughly similar to that found in the DAN accident statistics for air divers (Table A.1, below). Males dominate the mixed-gas population, with 87.5 percent of all cases involving men, compared to about 70 percent males in air-diving injuries. (Table A.2, below). Nitrox or mixed-gas certification does require an advanced diver certification, which might exclude many younger divers. It is possible that nitrox and mixed-gas diving do not have the same appeal to some divers for many reasons. Perhaps the additional training, the more "technical" appearance of nitrox and mixed-gas diving, the additional cost, or the increased risk of having oxygen toxicity problems may be discouraging for the majority of recreational air divers.

Table E.1 ***Age Distribution of Nitrox or Mixed-Gas Accident Cases***

Age	1995 Percent
20-24	18.8
25-29	31.3
30-34	18.8
35-39	18.8
40-44	12.5
TOTALS	**100.0**

Table E.2 ***Sex of Nitrox or Mixed-Gas Accident Cases***

Sex	1995 Percent
Female	12.5
Male	87.5
TOTAL	**100.0**

Because most nitrox and mixed-gas divers generally have an advanced certification, it is not surprising to find that a majority of these divers were certified at the advanced or instructor level (Table A.3, page 123). In a similar manner, all divers had performed at least 40 dives and the majority had performed over 100 dives. Six of the divers had been diving for 10 years or more, and one diver had been diving for less than two years (Table A.4, page 123).

Table E.3 *Certification Level of Nitrox or Mixed-Gas Accident Cases*

Certification	Male	Female	Totals	1995 Percent
Student	0	0	0	0.0
Basic/Open Water	1	0	1	6.3
Advanced	6	0	6	37.5
Divemaster	0	1	1	6.3
Instructor	6	1	7	43.8
Other	1	0	1	6.3
TOTALS	**14**	**2**	**16**	**100.0**

Table E.4 *Diver Experience Among Nitrox or Mixed-Gas Injured Divers*

Male/Female	Total Lifetime Dives					
Years Diving	41-60	61-80	81-100	101-120	121+	TOTAL
0-1	0	0	1	0	0	1
2-3	1*	0	0	0	2	3
4-5	1	0	1	0	1	3
6-7	0	0	0	0	2	2
8-9	0	0	0	0	2	2
10-11	0	0	0	0	0	0
12-13	0	0	0	0	0	0
14-15	0	0	0	0	0	1
16-17	0	0	0	0	1	1
18-19	0	0	0	0	1	1
20-21	0	0	0	0	2/1*	3
TOTALS	**2**	**0**	**2**	**0**	**12**	**16**

** Female divers*

Decompression Illness

Decompression illness is the more general term for arterial gas embolism (AGE) and decompression sickness (DCS I and DCS II). Among the nitrox and mixed-gas injury data, there was a prevalence of DCS II (neurological — Table E.5, page 124). Few or no AGE cases being reported would not be unexpected, since this group of divers are more frequent, more experienced divers and have received additional training in scuba diving and mixed-gas use.

Table E.5 *Conventional Disease Categories*

Final Diagnosis	Frequency	Percent
DCS I	2	12.5
DCS II	14	87.5
AGE	0	0.0
TOTALS	**16**	**100.0**

Three out of 16 divers experienced one of their DCS symptoms prior to their last dive, but continued to dive (Table E.6, below). More mixed-gas divers took oral fluids and aspirin than oxygen as a first aid treatment for DCS (Table E.7, below). The percentage of mixed-gas divers (43.7 percent) who used oxygen as first aid is similar to that of air divers (55.4 percent). Emergency medical oxygen may be more available in this more technical type of diving community.

Seven of 16 divers had residual symptoms after recompression therapy was completed. One diver was left with pain and six divers had at least one neurological symptom.

Both pain-only (DCS I) cases called for assistance within 12 hours of the start of symptoms, but one diver waited an additional day and a half to report for recompression. A similar pattern was noted in the DCS II cases, where divers tended to report for treatment with a prolonged interval after calling for assistance.

Table E.6 *DCI Symptoms Prior to Last Dive*

Sex	Frequency	Total	Percent
Male	2	14	14.3
Female	1	2	50.0
TOTAL	**3**	**16**	**18.8**

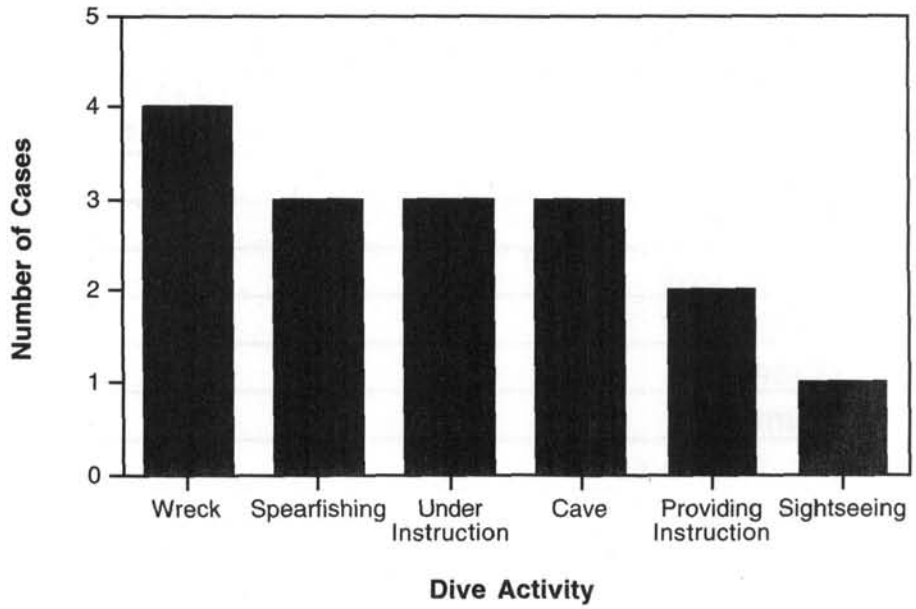
Table E.7 *First Aid Used*

First Aid	# of Divers
Oral fluids	12
Aspirin	8
Oxygen	7
Position	3
TOTAL	**16**

Dive Profile Information

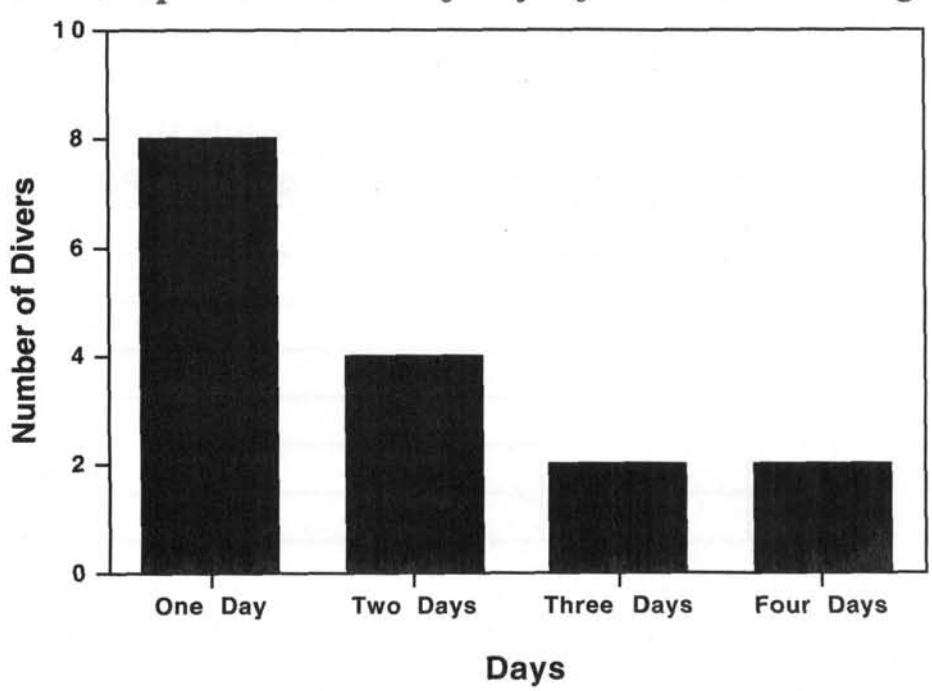
The activity of mixed-gas diving appears to be linked to more specialized dive activities, compared to recreational air divers in the 1995 accident database (Graph A.1, below). Wreck and cave divers were among the first scuba divers to utilize mixed gases for recreational scuba. It is not surprising to find these activities are more popular in this limited population.

Graph E.1 ***Primary Dive Activity***



Nine out of 16 divers were injured on the first day of diving (Graph E.2, below). The same trend is found in air divers, where more injuries occur on the first day of diving. The reasons for this are not clear. One can only speculate about the many characteristics of the dive and unique individual susceptibilities that may lead to a dive injury occurring on the first day of diving. Mixed-gas divers do tend to be more active divers, with 81.2 percent having dived in the preceding 30 days. This compares to only 53.6 percent of recreational air divers.

Graph E.2 ***Number of Days of Continuous Diving***



The style of diving is different for mixed-gas divers and is reflected in the dive profile data (Table E.8, below). The majority dived to 80 feet or greater, making square, single dives. The low number of divers doing no-stop dives suggests a more task-oriented dive, which does not take advantage of the decompression savings of using a lower partial pressure of nitrogen. Rapid ascents were reported as a factor in only two cases of DCS.

Table E.8 ***DCS Dive Attributes Among Mixed-Gas Injured Divers***

Attribute	Frequency	1995 Percent
≥ 80 fsw	13	81.3
Square	10	62.5
Single Dive	10	62.5
Single Day	8	50.0
Exertion	8	50.0
Current	7	43.8
No decompression	5	31.3
Rapid ascent	2	12.5

Eleven of 16 mixed-gas divers (68.7 percent) were using a computer to help calculate their dive (Table E.9, below). The similarities in computer and table users were in the depth of diving and the use of decompression diving. The number of divers in each group is really too small to make a valid comparison, but there appear to be some differences between groups.

Among the 16 mixed-gas divers, three had equipment problems; one had regulator difficulty; one reported unfamiliarity with some of the equipment; and one diver listed an O-ring failure as an equipment problem.

Table E.9 ***Attributes of Computer and Table Divers***

	Computer Divers		Table Divers	
Attribute	Frequency	Percent	Frequency	Percent
≥ 80 fsw	9	81.8	4	80.0
Decompression	8	72.7	3	60.0
Repeat Dive	8	72.7	2	40.0
Multi Day	7	63.6	1	20.0
Exertion	7	63.6	1	20.0
Single Day	4	36.4	4	80.0
Multilevel	4	36.4	2	40.0

Summary

Like computer-assisted diving, nitrox and mixed-gas diving appear to be a permanent part of the recreational diving community. The number of cases collected by DAN must be expanded before any meaningful analysis can be produced. Although mixed-gas diving is becoming more common, it does not appear to be popular with everyone. This may be for a variety of reasons, but it has a high-profile "technical" appearance which may not be consistent with the general public's view of recreational scuba.

The injuries reported among nitrox and mixed-gas divers are not unlike those injuries reported in air divers. There do appear to be differences in these two groups of injuries, however. It appears that most injured nitrox or mixed-gas divers were using these gases to extend their bottom times. This is in contrast to a diver who would follow air decompression tables breathing a high oxygen/nitrox mix to reduce his risk of decompression sickness.

There are risks with nitrox and mixed gas that are not present at the same depths in air diving, such as oxygen toxicity, which is potentially fatal at depth. Oxygen toxicity seizures have been reported in near-misses and fatal diving incidents. The few incidents reported in this series may indicate that the current guidelines and safety procedures are working to minimize this risk.

The decision to use nitrox or mixed gas in a reasonably safe manner must include proper certification training through one of the many training associations. It must also include the acknowledgement that mixed-gas diving has additional risks, and greater caution must be extended to control these risks and other factors that may influence mixed-gas diving.

Appendix F
Diving Definitions

Arterial Gas Embolism — Also refered to as AGE, an embolism is when gas bubbles are found in the arterial system. This is generally caused by air passing through the walls of the alveoli into the bloodstream.

Buoyancy Control — The ability to maintain neutral buoyancy. Common causes of buoyancy problems include a current pushing a diver either up or down, being either over- or underweighted, overinflation of the buoyancy 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 requiring staged in-water stops before continuing to the surface.

Decompression Illness — Also referred to as DCI, decompression illness is a term to describe dysbaric injuries related to scuba diving. This diagnosis stems from the uncertainties in many cases about the mechanistic causation of neurological symptoms. Moreover, it is sometimes impossible to differentiate clinically between neurological DCS and AGE. An alternative approach has been suggested, in which the clinical manifestation of a patient's decompression syndrome are described without attempting to determine the pathophysiology. The term "decompression illness" (DCI) is suggested to encompass all manifestations of decompression barotrauma and/or decompression sickness.

Decompression Sickness — Also referred to as DCS, decompression sickness is syndrome formed by bubbles of inert gas forming in the tissues and bloodstream, which evolves from too rapid an ascent from compressed gas diving. DCS is manifested in two major forms, DCS I and DCS II.

DCS I — decompression sickness typified by joint pain, skin symptoms and/or muscle pain.

DCS II — decompression sickness which includes symptoms involving the central nervous system, respiratory system or circulatory system. DCS II is further broken into the following subcategories.

DCS II Severe — includes neurological symptoms including unconsciousness, semiconsciousness, paralysis, speech and visual disturbances, difficulty walking, bowel and bladder problems, and convulsions.

DCS II Mild — includes all other neurological symptoms (refer to Table 4.1, page 46) for a list of all symptoms).

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 (such as 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 years' Experience — The diver had been diving for less than 24 months on the day of interest.

Mixed Gas — Any breathing medium containing an inert gas other than nitrogen. This could be a mix where helium has been added to air or a mix containing only oxygen or helium (or another inert gas).

Multiday — More than one day of diving was done in this particular dive series. Multiday 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).

Nitrox — Essentially a mixed gas which contains an oxygen percentage other than 21 percent. "Oxygen-enriched air" or "enriched-air nitrox" refer to nitrox mixtures with oxygen levels greater than 21 percent. The most common nitrox mixtures are NOAA Nitrox I and NOAA Nitrox II, 32 percent oxygen and 36 percent oxygen, respectively.

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 made 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.

Technical Dive — In this report, a technical dive is defined as one in which one of the following conditions existed:

- Diving to more than 130 feet/40 meters;
- Using breathing mixture other than compressed air; or
- Decompression or overhead diving (diving in shipwrecks or caves).

Appendix G
Abstracts — 1995-96

Caruso JL, Uguccioni DM, Mebane GY, Dovenbarger JA. Recreational Diving Fatalities in the U.S., 1990-1994: Patterns and Trends. Proceedings Annual Scientific Meeting, Undersea and Hyperbaric Medical Society, May 1996. Undersea and Hyperbaric Medicine 23(suppl): 60, 1996.

Dear G de L, Dovenbarger JA, Willingham BL, Walker KP, Stolp BW, Moon RE, Bennett PB. A Two-year Survey of Emergency Calls to the Divers Alert Network. Undersea and Hyperbaric Medicine 22(suppl): 56, 1995.

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Dovenbarger JA, Uguccioni DM, Corson K. Analysis of Trends in Recreational SCUBA Injuries and Fatalities. Undersea and Hyperbaric Medical Society Gulf Coast Meeting, New Orleans, Louisiana. March, 1995.

Gerth WA, Vann RD. A Statistical Bubble Dynamics Model of Decompression Sickness Risk for Diving and Altitude Decompressions. Proceedings Annual Scientific Meeting, Undersea and Hyperbaric Medical Society, May 1996. Undersea and Hyperbaric Medicine 23(suppl): 25, 1996.

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Moon RE, Vann RD, Bennett PB. The Physiology of Decompression Illness. Scientific American, pp 54-61, August 1995.

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Moon RE, Massey EW, Hanson MW, Coleman RE. Persistent Altitude Induced Symptoms After DCI: Investigation Using Position Emission Tomography (PET). Undersea and Hyperbaric Medicine 22(suppl): 63, 1995.

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Uguccioni DM and Dovenbarger JA. Equipment Problems in Recreational Diving. Undersea and Hyperbaric Medical Society Gulf Coast Meeting, New Orleans, Louisiana. March, 1995

Uguccioni DM, Vann RD, Smith LR, Butler, Roye DB, Ruer RD. Effect of Safety Stop on Venous Gas Emboli After No-stop Diving. Undersea and Hyperbaric Medicine 22(suppl): 38, 1995.

Vann RD, Bute BP, Uguccioni DM, Smith LR. Repetitive Recompression in DCI Therapy. Proceedings Annual Scientific Meeting, Undersea and Hyperbaric Medical Society, May 1996. Undersea and Hyperbaric Medicine 23(suppl): 33, 1996.

Vann RD, Gerth WA, Denoble PJ, Sitzes CR, Smith LR. A Comparison of Recent Flying After Diving Experiments with Published Flying After Diving Guidelines. Proceedings Annual Scientific Meeting, Undersea and Hyperbaric Medical Society, May 1996. Undersea and Hyperbaric Medicine 23(suppl): 36, 1996.

Vann RD, Gerth WA, Denoble PJ, Sitzes CR, Shuster B. Project Dive Safety: An Overview. Undersea and Hyperbaric Medicine 22(suppl): 58, 1995.

Vann RD, Gerth WA, Denoble PJ, Smith LR. DCS and flying after diving. Undersea and Hyperbaric Medicine 22(suppl): 34, 1995.

Vann RD, Bute BP, Uguccioni DM, Smith LR. Prognostic factors in DCI in recreational divers. UHMS /DAN/USN/ Asthma Society Workshop Proceedings, 1995.

Appendix H

Total Reported Cases by Year and Region: 1986 - 1992

1992	SW	NW	MW	GU	PA	NE	SE**	TOTALS
DCS-I	25	17	20	24	21	43	82	232
DCS-II	59	47	27	59	63†	24	276	555
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	226
DCS-II	60	8	10	37		34	193	342
AGE	13	1	2	7		15	58	96
No DX reported					31			31
TOTALS	**104**	**17**	**29**	**75**	**31**	**77**	**362**	**695***

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***

Total Reported Cases by Year and Region: 1986 - 1992

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.*
\+ *Hawaii only reports number of cases treated.*
++ *No Treatment represents cases with no treatment, refused treatment, or spontaneous resolution.*

Notes