+ Divers Alert Network +

Thalmann

Report on Decompression Illness and Diving Fatalities

The DAN Annual Review of Recreational Scuba Diving Injuries and Deaths Based on 1996 Data

1998 Edition

US$25

Report on Decompression Illness and Diving Fatalities

1998 Edition

The annual review of scuba diving injuries and deaths based on 1996 data

by

Divers Alert Network

Divers Alert Network

This 1998 edition covers injuries and fatalities that occurred from Jan. 1-Dec. 31, 1996.

Divers Alert Network's *Report on Decompression Illness and Diving Fatalities* presents self-reported, retrospective data from hyperbaric treatment facilities. This edition covers reports on decompression illness and diving-related fatalities that occurred in the calendar year 1996 — Jan. 1 - Dec. 31, 1996. It is referred to throughout as the *Report*, or the 1998 edition of the *Report*.

In 1996, 935 cases of decompression illness (DCI) were reported to DAN through telephone contact with hyperbaric treatment facilities. DAN received *Diving Accident Reporting Forms (DARFs)** on 672 cases. Of these 672 reports, 483 DCI cases met the criteria for inclusion in the DAN 1996 database (see Page 19). Trends in the injury database are reported on a 10-year period, from 1987 through 1996. The *Report* also reviews 85 recreational scuba fatalities that occurred in 1996 involving U.S. and Canadian citizens worldwide.

The DAN reporting forms on injuries, fatalities and dive incidents which have previously appeared as appendices in past editions of this *Report* have been removed. Copies of these reporting forms may be obtained by calling DAN's Medical Department at (919) 684-2948.

The DAN *Dive Incident Reporting Form*, 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 photo by DAN member Denis Tapparel.
Cover design by Phillip Daquila.

** Note: In 1998 DAN revised the* Diving Accident Reporting Form (DARF) *into a more standardized reporting format known as the* Diving Injury Report Form, *or* DIRF. *The DIRF has been developed to describe symptoms more accurately, enhance diagnosis, assist in classification and reduce uncertainty about the diagnosis of DCI.*

Acknowledgments

Data for the *1998 Report on Decompression Illness and Diving Fatalities* has been collected and assembled by DAN employees and associated staff. These contributions range from injury follow-up calls, data entry, editing, proofreading and compiling the final report. DAN wishes to recognize the following people for their important contributions:

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DAN Senior Medical Staff

Guy de L. Dear M.B., FRCA	*Bryant Stolp M.D., Ph.D.*
Richard Moon M.D.	*Edward D. Thalmann, M.D.*

DAN Volunteer Physicians

James Caruso M.D.	*Karl Peter Fritz M.D.*
Bruce Cohen M.D.	*Tong Joo Gan M.D.*
Christopher DeBacker M.D.	*James Karegeannes M.D.*
David N. DuBois M.D.	

Find DAN's Dive Incident Reporting Form on its Worldwide Web pages at www.dan.ycg.org

DAN's new Diving Injury Report Forms are available through DAN's Medical Department.

DAN Regions and Regional Coordinators for Hyperbaric Treatment

Divers Alert Network utilizes a network of 262 hyperbaric chambers in the United States and around the world to report decompression illness (DCI) injuries. The DAN network is now divided into eight regions, each overseen by a Regional Coordinator.

International Headquarters and Southeast Region — *Alabama, Georgia, North Carolina, South Carolina, Tennessee*

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, 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, 347 N. Kuakini Street, Honolulu, HI 96813

Florida and Caribbean Region — *Florida and Caribbean Basin*

Harry Heinitsh, M.D. and Mr. Marc R. Kaiser
Diving Medical Center at Mercy Hospital, 3663 South Miami Avenue, Miami, FL 33133

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DAN — *Your* Dive Safety Association

DAN was founded in 1980 to provide an emergency hotline to serve injured divers and the medical personnel who care for them.

For scuba divers worldwide, DAN means safety, health and peace of mind. DAN is a 501 (c) (3) non-profit dive safety organization affiliated with Duke University Medical Center in Durham, N.C., and supported by the largest membership association of divers in the world.

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 America's Services to the Recreational Diving Community

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, Southeast Asia and Southern Africa 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.

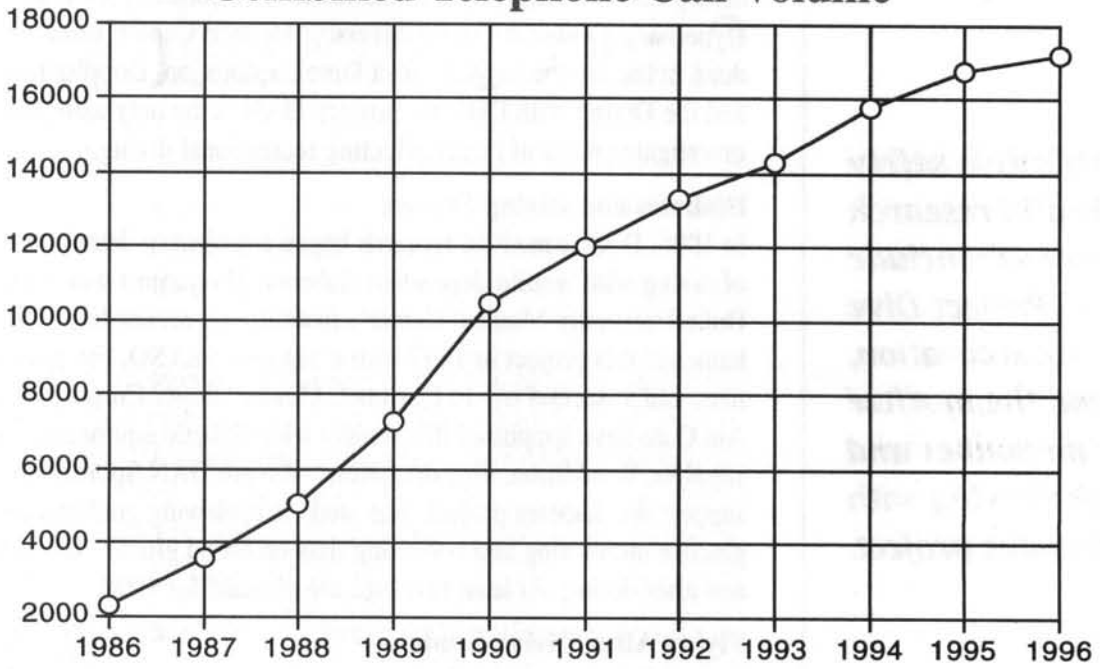
DAN's Mission

✦ ***DAN's historical and primary function is to provide emergency medical advice and assistance for underwater diving injuries, to work to prevent injuries 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 *or collect at* (919) 684-4DAN (-4326)

The 24-Hour Diving Emergency Hotline is DAN's premier service. The medical information specialists and DAN physicians offer emergency consultation and referral services to injured divers worldwide. In 1996, 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.

In 1996, DAN took more than 2,000 calls for emergency assistance from members and divers.

■ 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 information specialists are there to help them. 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. The DAN Medical Department received 13,870 information calls in 1996. Since DAN's beginnings more than 17 years ago, over 124,000 callers have been assisted through the use of these telephone services.

■ DAN Dive Health and Safety Research

DAN's Research Department is dedicated to scientific medical study of diving health issues. Much of the research is done at F.G. Hall Hypo-Hyperbaric Center at Duke University Medical Center; research is also done in the field through Project Dive Exploration, Doppler field studies and the Diving with Diabetes project. DAN is the only association that investigates medical issues affecting recreational diving.

DAN's dive safety and health research projects include Project Dive Exploration, the Flying After Diving studies and the Diving with Diabetes project.

Diabetes and Diving Project

In 1996, DAN's medical research began a project to determine the risks of diving with insulin-dependent diabetes. The project was approved by Duke University Medical Center's institutional review board. DAN launched this project in 1997 with a trip to UNEXSO, Freeport, Bahamas, and a second trip to Cozumel, Mexico. Bayer Corporation and Can Am Care have supported this project with diabetic equipment and supplies. In addition, dive operations who are DAN Sponsors help support the diabetes project. The study is reviewing guidelines for blood glucose monitoring and collecting data on blood glucose levels before and after diving. At least two trips are planned for 1998.

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 Exploration

Another current study is Project Dive Exploration, DAN's long-term collection of diving data. DAN researchers are currently using recording dive computers worldwide to collect information on dive profiles. The 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. **DAN's Doppler field studies**, ongoing for the past 10 years, have been incorporated as part of Project Dive Exploration.

U.S. Navy / DAN Survey of Recreational Divers

The U.S. Navy has asked DAN for assistance in conducting a survey of recreational divers to obtain information about demographics, experience and diving habits. In early 1998, a randomly selected group of DAN members will receive a survey form; participation is voluntary. The Navy has a new low-frequency sonar called SURTASS LFA (Surveillance Towed Array Sonar System Low Frequency Active). Like the sonar in current use, safe operating limits must be determined. This particular sonar may be audible for many miles, so the potential for incidental exposure is greater than with current sonar.

The Navy wants to find levels that will not cause problems in the recreational community and is conducting studies involving non-military-trained sport divers to look into the issue. DAN will not play any role in that study, nor will it play any role in recruiting subjects; the Navy will do that on its own. However, the Navy wants to determine how representative the subjects are of the sport diver population, and that's where DAN comes in.

In addition, this survey data will give the Navy an idea of the medical conditions present in sports divers, which may have to be taken into consideration in setting safe sonar operating limits.

Other Projects

Other major projects with which DAN personnel are involved take place at Duke's F.G. Hall Hypo-Hyperbaric Center. These include a NASA-funded study to determine how exercise and microgravity affect decompression illness in astronauts during "space walks," or extravehicular activity (EVA). There are U.S. Navy-funded projects about dive computers and a diving database, as well as a project funded by Special Operations Command to study oxygen-enhanced breath-hold diving.

This research requires the use of expensive, specialized hypo-hyperbaric scientists and physicians, software development and technical staffing. 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.

■ DAN Support to the Dive Medical Community

Through 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 injury 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.

DAN offers a Recompression Chamber Assistance Program to help educate and maintain hyperbaric chambers and a Diving Preferred Provider Network to help manage the costs of treatment.

DAN founded the world's most popular oxygen first aid program, launched in 1991. More than 60,000 divers and 7,000 diving professionals have been trained under this program.

As of January 1998, more than 63,000 divers and over 7,200 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 injuries. 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, divers certified as oxygen providers 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, order DAN products, 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 Exploration, Flying After Diving and Diabetes and Diving. Interested participants can, at no cost, download software for collecting information about dive profiles and diving injuries.

DAN America Membership Services

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 injury insurance and the exclusive DAN Tag™, diving's only emergency ID.

As of October 1997, approximately 170,000 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 service provides up to $100,000 emergency medical evacuation assistance for *any* injury or illness — dive-related or not — incurred at least 50 miles from home by a DAN member or a DAN family member.

DAN Dive Injury 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 (800) 446-2671, 9 a.m.-5 p.m. Eastern Time, Monday-Friday.

** If the loss was a result of being injured in a dive accident.

■ *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 Injury Insurance

DAN members are eligible for three different levels in insurance — the Master, Plus and Standard Plans — in addition to DAN membership. In 1996, DAN significantly improved the benefits of each level. The DAN Master Plan, in combination with DAN membership benefits, offers up to $260,000 of protection for divers and travelers.

DAN pioneered dive injury 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

Only DAN members may purchase the DAN Tag, the first medical ID tag created exclusively for divers.

by any other organization at the time, and provided DAN members with additional benefits. Prior to these DAN programs, 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.

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

■ DAN Dive Safety and Health Products

DAN members receive a special member price on all DAN 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 and diver first aid kits. DAN's Product Listing displaying these and other DAN products is available in every issue of *Alert Diver*. Selected products from DAN's Product Listing are available for sale on DAN's Web site.

■ 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.

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

Dive and travel medical emergencies can happen at any time of day, 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 injury 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/or 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 Injuries

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 calendar year 1996 on treated cases of decompression illness and on confirmed fatalities. Published in 1998, it is referred to throughout as the *Report*, or the 1998 edition of the *Report*, and is the tenth 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 section, beginning with section 6.0, discusses fatalities involving recreational scuba divers. DAN's injury database now contains data on 4,437 cases of DCI treated over the past nine years and 3,508 cases since 1990.

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Decompression Illness *(DCI)* Defined

Decompression illness, or DCI, 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 breath-holding; 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 formed in the tissues and bloodstream after scuba diving. DCS usually results from a deep dive or a prolonged exposure to breathing compressed gas at depths greater than 20 feet / 6.1 meters. Symptoms may be confined to the musculoskeletal system and consist of joint or muscle pain. DCS may also involve the central nervous system with symptoms of numbness, tingling and other complaints,

Why DAN Collects This Data

DAN collects dive injury data to obtain details on how decompression sickness and arterial gas embolism occur in recreational scuba divers. This information is also valuable in

determining trends or changes in the types of diving injuries and symptomatology that occur, 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.

DAN collects data on dive injuries in an effort to help inform and educate the diving community — from recreational 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 1994-1996 are shown in Table 1.1 (Page 15). Appendix H shows totals for 1986-1993.

Decompression Illness Cases

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

- **Type I decompression sickness**, or DCS-I — refers to skin bends, fatigue or pain involving joints or muscles;
- **Type II decompression sickness**, or DCS-II — includes neurological and cardiorespiratory symptoms;
- **Arterial gas embolism**, or 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 number of cases treated in 1996 separated according to records received from the DAN region in which treatment occurred. 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 1996, separated by regions and states within that region. The Caribbean basin is represented separately in this table.

The numbers for 1996 represent the total number of treated cases reported from 39 states, 16 countries and two U.S. territories — U.S. Virgin Islands and Puerto Rico. Although there may be some non-U.S. or Canadian 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. chambers, and U.S. residents who are treated in non-U.S. chambers.

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

1996	Other*	SW	NW	MW	GU	PA	NE	SE+	TOTALS
DCS-I	5	38	18	13	29	5	37	115	260
DCS-II	14	73	36	24	68	22	44	248	529
AGE	0	18	2	5	4	9	5	47	90
No classification assigned	0	0	0	4	0	0	22	30	56
TOTALS	**19**	**129**	**56**	**46**	**101**	**36**	**108**	**440**	**935**

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 classification assigned	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 classification assigned	14	40	0	11	1	77	6	53	202
TOTALS	**33**	**156**	**68**	**50**	**111**	**101**	**133**	**512**	**1,163**

* 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 1996 by Region*

Southwest Region	DCS-I	DCS-II	AGE	TOTALS
Arizona	6	3	1	10
California	30	64	15	109
Nevada	0	1	2	3
Utah	2	5	0	7
TOTALS	**38**	**73**	**18**	**129**

Northwest Region	DCS-I	DCS-II	AGE	TOTALS
Alaska	1	0	0	1
Idaho	1	0	0	1
Montana	1	2	1	4
Oregon	1	8	0	9
Washington	14	26	1	41
TOTALS	**18**	**36**	**2**	**56**

TABLE 1.2 *(continued)* *Total Cases Treated & Reported in 1996 by Region*

The numbers for 1996 represent the total number of treated cases reported from 39 states, 20 countries and two U.S. territories — U.S. Virgin Islands and Puerto Rico.

Midwest Region	DCS-I	DCS-II	AGE	TOTALS
Illinois	8	12	0	20
Indiana	1	2	1	4
Kentucky	0	1	0	1
Michigan	1	2	1	4
Minnesota	1	2	1	4
Nebraska	0	1	0	1
Ohio	2	2	0	8* (4)
Wisconsin	0	2	2	4
TOTALS	**13**	**24**	**5**	**46**

Gulf Region	DCS-I	DCS-II	AGE	TOTALS
Colorado	1	17	2	20
Louisiana	5	11	0	16
Mississippi	0	1	0	1
Missouri	3	2	0	5
Oklahoma	3	1	0	4
Texas	17	36	2	55
TOTALS	**29**	**68**	**4**	**101**

Pacific Region	DCS-I	DCS-II	AGE	TOTALS
Hawaii	5	22	9	36
TOTALS	**5**	**22**	**9**	**36**

Northeast Region	DCS-I	DCS-II	AGE	TOTALS
Connecticut	0	7	2	9
Maine	2	8	0	10
Maryland	1	2	0	3
Massachusetts	10	9	1	20
New Jersey	5	7	0	12
New York	10	3	1	36* (22)
Pennsylvania	8	6	0	14
Rhode Island	0	1	0	1
Virginia	1	1	1	3
TOTALS	**37**	**44**	**5**	**108**

- In the Totals Column the number in parenthesis represents the number of cases that were not classified by diagnosis.

TABLE 1.2 *(continued)* *Total Cases Treated & Reported in 1996 by Region*

Southeast Region	DCS-I	DCS-II	AGE	TOTALS
Alabama	6	4	0	10
Florida	53	135	36	233* (9)
Georgia	12	3	1	16
North Carolina	2	0	0	23* (21)
South Carolina	2	2	0	4
Tennessee	1	1	1	3
TOTALS	**76**	**145**	**38**	**289**

Caribbean Basin	DCS-I	DCS-II	AGE	TOTALS
Bahamas	3	5	0	8
Barbados	0	2	0	2
Belize	0	11	0	11
Bermuda	1	1	0	2
Bonaire	0	4	0	4
Cayman	5	10	3	18
Honduras	12	2	0	14
Jamaica	0	3	1	4
Mexico	12	43	5	60
Panama (Canal Zone)	0	1	0	1
Puerto Rico+	0	2	0	2
Saba	1	2	0	3
St. Thomas+	2	4	0	6
Turks & Caicos	3	13	0	16
TOTALS	**39**	**103**	**9**	**151**

+ *U.S Territories*

Other	DCS-I	DCS-II	AGE	TOTALS
Australia	1	1	0	2
Fiji	0	5	0	5
Palau	2	8	0	10
Philippines	2	0	0	2
TOTALS	**5**	**14**	**0**	**19**

* In the Totals Column the number in parenthesis represents the number of cases that were not classified by diagnosis.

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. chambers, and U.S. residents who are treated in non-U.S. chambers.

Collection of DAN Database Cases

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

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

Divers Alert Network utilizes a network of 262 hyperbaric chambers in the United States, Canada and around the world to report decompression illness (DCI) injuries. The DAN network is now divided into eight regions, each overseen by a Regional Coordinator (see the entry on Page 4 for the listing of specific regions and their respective Regional Coordinators). The newest region included in the network has been created by making Florida and the Caribbean Basin one separate region.

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 case 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.

DAN is initially informed of a diving injury through phone calls, but in order to enter the cases into its database, DAN must receive a completed *Diving Accident Reporting Form.* Each year, DAN surveys hyperbaric treatment centers to solicit their participation in the reporting program. In 1996, of the 935 cases of treated DCI reported to DAN by phone, DAN received only 672 DARFs reporting these incidents.

With DAN's DARFs, the names and identifying personal information are confidential and not available to anyone outside DAN's Medical and Research Departments. Injury data are not used to imply individual fault or blame but to determine the cause of scuba injuries 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.

In many instances there is a significant delay from completion of a treatment and the receipt of the DARF by DAN. Only DARFs for cases treated in calendar year 1996 received by DAN before July 1, 1997, are included in this report. Divers treated at more than one hyperbaric facility are only counted once, unless they were injured a second time.

When an injured diver's case is received at DAN, it is logged into a tracking database. DAN's medical information specialists then contact the diver by phone to 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 the case is in litigation. Patients with residual symptoms at the time of follow-up are contacted by DAN three months after the injury or until they no longer have residual symptoms.

** Note: In 1998 DAN revised the* Diving Accident Reporting Form (DARF) *into a more standardized reporting format known as the* Diving Injury Report Form, *or* DIRF. *The DIRF has been developed to describe symptoms more accurately, enhance diagnosis, assist in classification and reduce uncertainty about the diagnosis of DCI.*

Inclusion Criteria Explained

Of the 672 DARFs received at DAN, 483 met the criteria for inclusion in the DAN injury database. This represents 72 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.
- The only individuals used who were conducting a task are scuba instructors or divemasters providing dive instruction.
- If treated in a U.S. chamber, both U.S. and Canadian residents are included.
- If treated in a non-U.S. chamber,* only U.S. residents are included.
- Final diagnosis by the treating hyperbaric physician must be decompression illness.
- Cases must be received by July 1 of the following year for each collection year (e.g., July 1, 1997, for the 1996 reporting year).
- Each individual must have been contacted after treatment by the DAN medical staff.

A total of 166 cases were excluded from the DAN injury database for the reasons cited below.

Exclusion Criteria

- The injured diver was a commercial, occupational or scientific diver (n = 54);
- If treated in a U.S. chamber, the injured diver was not a resident of the U.S. or Canada; or, if treated in a non-U.S. chamber, the diver was not a U.S. resident (n = 44);
- DCI was not diagnosed; i.e., the injury was something else, such as ear barotrauma, pulled muscle or marine life envenomation (n = 43);
- The diver was using surface-supplied air or was breath-hold diving (n = 4);
- There were some cases in which no follow-up was possible by DAN medical staff because of a legal concern, or because the person was unable to be located (n=21).

A second recreational diver database of 23 cases exists for divers using gas mixtures other than air to make recreational dives. They are discussed in Appendix E (Page 117). Chapters 1-5 (Pages 13-61) include the 483 cases in which compressed air was breathed while diving.

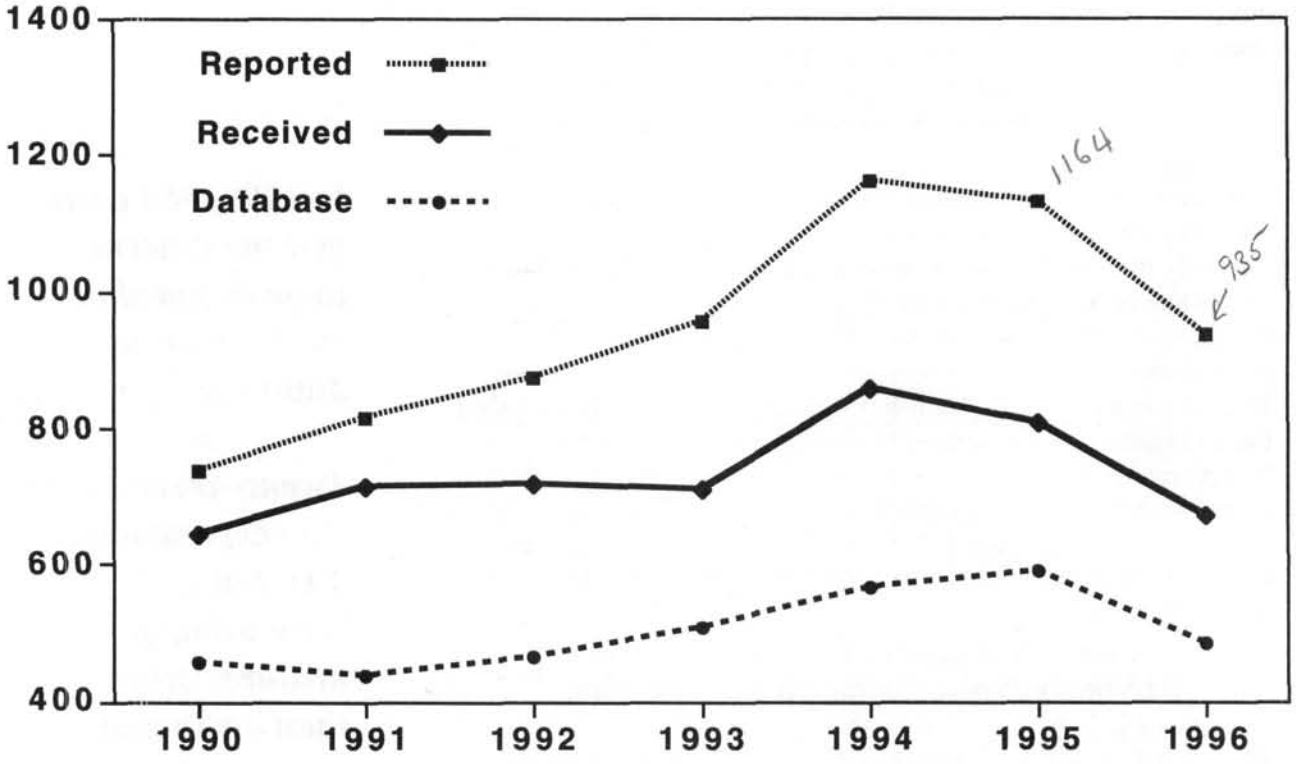
Graph 1.1 on the following page shows the dive injury reporting and collection trends since 1986. The top line indicates the total number of cases reported to DAN by telephone yearly (935 in 1996); the middle line represents the total number of DARFs sent to DAN for review (672); and the bottom line represents the total number of cases which met the criteria for inclusion in DAN's 1996 injury database (483).

In 1996, 483 cases met the criteria to be included in the DAN injury database.

Twenty-three divers who experienced a DCI injury were using gas mixtures other than air to make recreational or recreational /technical dives. They are discussed in Appendix E.

* *Canadian citizens treated in Canada are not reported to DAN.*

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



Database Cases

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

In a number of the 483 injury cases where air was breathed and which meet the inclusion criteria in 1996, 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.

The location of the dive injury for the 483 cases analyzed in this report are contained in Tables 1.3 and 1.4. These 483 cases represent those cases that met the inclusion criteria.

Table 1.3 (Page 21) shows the number of cases broken down by country (n = 483); and Table 1.4 on the following page represents the number of injuries treated in the U.S. states and territories (n = 302).

Tables 1.3 and 1.4 show where the injury occurred but do not necessarily indicate where the treatment was conducted.

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

Country	Frequency	Percentage
Antigua	1	0.2
Barbados	1	0.2
Bonaire	1	0.2
Costa Rica	1	0.2
Philippine Islands	1	0.2
St. Vincent	1	0.2
Tobago	1	0.2
Truk	1	0.2
Turks & Caicos	1	0.2
Australia	2	0.4
Bermuda	2	0.4
Fiji	2	0.4
British Virgin Islands	3	0.7
Palau	3	0.7
Antilles	4	0.8
US Territories	4	**0.8**
Canada	11	2.3
Belize	14	2.9
Honduras	14	2.9
Cayman Islands	16	3.3
Bahamas	21	4.3
Mexico	80	16.6
USA	**298**	**61.7**
TOTAL	**483**	**100.0**

Table 1.3 shows the number of cases broken down by country.

Table 1.4 represents the number of injuries treated in the U.S. states and territories.

Tables 1.3 and 1.4 show where diving injuries occurred but do not necessarily indicate treatment locations.

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

State	Frequency	Percent
Alabama	1	0.3
Colorado	1	0.3
Delaware	1	0.3
Missouri	1	0.3
New Mexico	1	0.3
Oklahoma	1	0.3
Georgia	2	0.7
Indiana	2	0.7
Louisiana	2	0.7
Maine	2	0.7
Michigan	2	0.7
Ohio	2	0.7
Oregon	2	0.7
Puerto Rico*	2	0.7
South Carolina	2	0.7
US Virgin Islands*	2	0.7
Utah	2	0.7
Vermont	2	0.7
Illinois	3	1.0
Nevada	3	1.0
Rhode Island	3	1.0
Virginia	3	1.0
Wisconsin	3	1.0
New York	4	1.3
North Carolina	4	1.3
New Jersey	5	1.7
Pennsylvania	5	1.7
Texas	15	5.0
Washington	28	9.2
California	31	10.2
Hawaii	35	11.5
Florida	130	42.9
TOTALS	**302**	**100.0**

* *US Territories*

Summary

- DAN telephone services refer hundreds of callers with suspected DCI to hyperbaric facilities. Not all callers follow the advice of the medical specialists or seek medical treatment.

- DAN's Medical Department made follow-up contacts with all of the hyperbaric chambers in its referral network to collate the total number of DCI injuries that were treated.

- In 1996, 935 cases of DCI were treated in the chambers that report their numbers to DAN. Of these cases, 672 Diving Accident Reporting Forms (DARFs) were sent to DAN. In 1996, 483 cases were included in the injury database.

- This report on 1996 data represents 52 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 injury database (see Pages 18-19).

- Collection efforts continue to improve and provide an effective method of collecting injury forms for review.

Since the first Report in 1987, 42 to 62 percent of all divers treated have been included in DAN's injury database.

This report on 1996 data represents 52 percent of the total number of divers treated.

To report an injury, a fatality or a near-miss in diving, call DAN's Medical Department at +1-919-684-2948

Divers Alert Network
The Peter B. Bennett Center
6 West Colony Place
Durham, NC 27705

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.

This section includes various characteristics (age, sex, diving experience, certification level, and more) of the divers in DAN's 1996 injury database. Two points to bear in mind when looking at this data: not all diving injuries reported to DAN via phone are included in the database, as noted in Section 1; and while DAN seeks to identify trends from year to year, the degree to which injured divers reflect the general diving population is unknown. DAN is attempting to learn more about the general diving population through the use of surveys to our DAN members.

The data for the years 1993-1996 are presented individually while the earlier data are presented in three-year increments.

Age Distribution in Injured Divers

Table 2.1 shows no significant change in the age distribution of injury cases from previous reporting years. Most of the cases continue to occur to divers in the age range from 25 to 44 years.

While DAN seeks to indentify trends, the degree to which injured divers reflect the general diving population is unknown.

Table 2.1 *Age Distribution of Injury Cases by Percentage*

Age	1996	1995	1994	1993	90-92	87-89
10-14	0.4	1.0	0.7	0.8	0.6	0.5
15-19	2.7	3.6	3.7	2.2	2.9	2.8
20-24	7.2	8.1	8.5	8.8	9.0	9.4
25-29	19.5	15.3	20.8	15.4	18.4	22.4
30-34	18.4	18.6	17.5	23.2	23.0	22.9
35-39	20.5	20.2	15.7	20.4	21.2	16.8
40-44	15.5	16.3	15.4	11.4	12.8	12.4
45-49	6.6	8.0	9.8	8.3	6.8	6.4
50-54	4.8	5.4	4.8	4.7	2.9	3.3
55-59	3.1	1.9	2.7	3.0	1.1	1.7
60-64	1.0	0.7	0.0	1.2	1.1	1.4
>=65	0.2	1.0	0.4	0.6	0.2	0.0
TOTALS	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table 2.2 ***Sex of 1987-1996 Injury Cases by Percentage***

Sex	1996	1995	1994	1993	90-92	87-89
Female	36.0	29.7	28.6	31.1	27.0	24.2
Male	64.0	70.3	71.4	68.9	73.0	75.8
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Sex of Injury Cases

Injured female divers represent 36 percent of divers treated in the 1996 database. There has been a slow overall increase in the percentage of females since 1987, when only 24.2 percentage of injured divers were female.

Diver Experience in Injury Cases

The column headings in Table 2.3 (Page 26) show the total numbers of lifetime dives 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, injured male divers had more years of diving than injured females.

In general, injured male divers had more years of diving than injured females. Sixty-seven percent of male injured divers and 56.7 percent of female injured divers had two or more years of experience or more than 20 dives. About 56 percent of all the males had four or more years of experience, while only 41 percent of all female injured victims had comparable experience. Ten percent of the females had more than 10 years' experience, while 31 percent of males had greater than 10 years' experience.

Table 2.3 also shows that injured male divers had more total lifetime dives than females. There were 57 percent of females with 40 or fewer lifetime dives, while only 38 percent of males reported 40 or fewer dives. Over 39 percent of males had 121 or more lifetime dives, while just over 27 percent of females reported the same numbers.

Overall, dive reporting reflects that females have tended to report injuries after fewer years of diving and after fewer dives.

Table 2.3 *1996 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	65	12	4	2	1	0	1	85
2-3	9	12	8	6	2	2	12	51
4-5	4	6	4	0	3	2	17	36
6-7	0	0	3	5	2	2	12	24
8-9	0	3	0	2	3	1	9	18
10-11	1	2	2	0	1	0	15	21
12-13	1	1	0	1	0	1	6	10
14-15	0	1	1	0	2	0	10	14
16-17	0	0	1	0	0	0	5	6
18-19	0	1	0	0	0	0	6	7
20-21	1	0	1	0	0	0	4	6
≥ 21	0	2	3	1	1	0	24	31
TOTALS	78	40	27	15	15	8	121	309

Female	Total Lifetime Dives								
Years Diving	0-20	21-40	41-60	61-80	81-100	101-120	121+	UNK	TOTAL
0-1	50	13	4	2	0	3	0	0	72
2-3	8	9	3	1	1	1	7	0	30
4-5	4	3	2	0	2	3	7	0	21
6-7	4	2	2	0	0	0	8	0	16
8-9	1	3	0	0	1	0	11	2	18
10-11	0	1	0	0	0	0	5	0	6
12-13	0	0	0	0	0	0	2	0	2
14-15	0	0	0	0	0	1	3	0	4
16-17	0	0	0	0	0	0	1	0	1
18-19	0	0	0	0	0	0	1	0	1
20-21	0	1	0	0	0	0	2	0	3
TOTALS	67	32	11	3	4	8	47	2	174

The numbers for divers with less than two years' experience have dropped, from 214 in 1995 to 157 in 1996.

Injuries by Years of Diving Experience

Table 2.4 (Page 27, top) shows a comparison of injuries according to years of experience. According to this table, it would appear that more divers report injuries earlier in their careers. After an initial jump in 1990-92, the trend in new divers is relatively flat. The numbers for divers with less than two years' experience (both male and female) have dropped from 1995 (from 214 in 1995 to 157 in 1996). The number of females with six to 11 years of diving experience has increased significantly in 1996.

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

Years Diving	Sex	1996	1995	1994	1993	90-92	87-89
<2 Years	Male	27.5	30.1	25.0	28.3	26.5	19.2
	Female	41.4	50.9	49.5	44.9	46.8	39.0
2 to 5 Years	Male	26.8	28.4	27.9	24.3	31.6	28.1
	Female	27.0	29.1	28.4	35.4	32.9	32.8
6 to 9 Years	Male	14.2	11.8	14.6	13.1	12.7	15.6
	Female	20.7	10.9	13.6	8.2	9.9	18.2
≥ 10 Years	Male	31.4	29.6	32.9	34.3	29.2	37.1
	Female	10.9	9.1	7.4	11.4	10.4	9.9

Table 2.5 *Certification Level of 1988-1996 Injury Cases by Percentage*

Certification	Male	Female	Totals	1996	1995	1994	1993	90-92	87-89
Student	5	4	9	1.9	0.7	1.9	4.5	1.9	1.3
Basic/ Open Water	113	95	228	47.2	49.2	47.1	47.5	49.7	49.7
Advanced	86	51	137	28.4	29.8	26.7	25.6	25.4	25.9
Divemaster	37	9	46	9.5	7.6	9.0	7.6	8.0	5.6
Instructor	26	11	37	7.7	8.3	12.5	12.4	10.4	10.9
Commercial	1	0	1	0.2	0.5	0.0	0.0	0.3	1.3
Other	16	3	19	3.9	3.1	1.6	2.2	2.8	1.8
None	5	1	6	1.2	0.8	1.2	0.2	1.3	1.2
Unknown	0	0	0	0.0	0.0	0.0	0.0	0.2	2.3
TOTALS	**309**	**174**	**483**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Certification Levels in Diving Injuries

As seen in Table 2.5 (directly above), the percentage of students reporting injuries remains low. With a greater emphasis on safety during diver training, one would expect that injuries among student divers would be minimal. 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*.

An upward trend for injuries in advanced divers, which appeared through 1995, leveled off in 1996. The number of injured divers reporting no certification has remained relatively constant.

An upward trend for injuries in advanced divers, which appeared through 1995, leveled off in 1996.

Diving Intensity in Injured New Divers

1996 saw a decrease in dive injuries with the last dive to 80 feet / 24 meters or deeper.

New or *Infrequent Divers* are divers who have been diving for less than two years or who have 20 or fewer lifetime dives. These divers accounted for approximately 40 percent of all injured divers in 1996.

In 1996 there was a decrease in dive injuries where the last dive was to 80 feet / 24 meters or deeper. The fraction who reported diving outside computer or table limits increased from last year, and divers reporting injuries who had 20 dives or less also increased. Thirty-two divers were excluded from the "outside limits" category because they were not using any method to calculate or plan their dive.

Table 2.6 *New Diver Profile Traits*

Traits	1996	1995	1994	1993	90-92	88-89
≤20 Dives	77.1	69.7	68.9	78.4	72.0	73.4
Square Dives	49.5	48.8	56.9	63.3	50.9	55.2
Repeat Dive	60.9	58.0	61.3	62.1	61.6	55.2
Diving ≥ 80 fsw	51.0	63.7	55.5	53.0	60.8	52.1
Rapid Ascent	40.6	40.0	31.4	32.3	35.6	42.2
Last Dive ≥ 80 fsw	21.4	27.6	27.8	24.0	30.3*	0.0
Outside Limits	16.7	10.5	10.8+	18.2	22.6	23.4
No Table/Computer Use	6.8	6.1	7.9	-	-	-
	n=192	n=245	n=213	n=198	n=528	n=192

** from 1992 only*
+ refers to 195 cases

Current Medical History in Divers With DCI

Divers who reported diving outside computer or table limits, as well as those with 20 dives or less, increased.

Table 2.7 (Page 29, top) shows the organ system 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 injuries who reported having asthma as a fraction of all reported accidents was 1.4 percent for 1996, half of that reported in 1995, (2.9 percent). Table 2.8 (Page 29) shows that the percentage of injured divers without current medical problems has remained fairly constant since 1990, between 74 and 78 percent.

Table 2.7 *Current Medical History of DCI Cases for the Years 1988-1996*

Problem	1996	1995	1994	1993	90-92	88-89
None	371	433	430	396	994	462
Spine/Back	19	24	24	13	51	29
GI/Abdomen	18	16	15	15	37	13
Muscl/Skel System	10	12	14	7	54	23
Mental/Emotion	8	12	9	4	27	12
Asthma	7	17	14	5	21	11
Chest-lung	6	10	10	7	37	13
Limb/Joint DCS	5	12	6	1	16	5
Neuro/Nerv System	4	2	8	4	17	4
Cir/Blood	2	2	11	5	12	9
Chest-heart	2	7	4	4	12	10
Eye	2	5	3	4	6	5
Brain	0	1	1	1	2	-
No response	0	0	0	1	1	0
Other	37	52	37	55	125	87
TOTALS	**491***	**605***	**586***	**522***	**1412***	**683***

** Some divers reported multiple health problems.*

Table 2.8 *Percentage of Divers Without Current Health Problems*

Current	1996	1995	1994	1993	90-92	87-89
Frequency	371	433	430	396	994	636
Percent	76.8	74.4	76.0	78.0	75.0	68.5

Previous Medical Problems in Divers with DCI

Table 2.9 (Page 30, top) shows that the spectrum of previous medical problems among injured divers has not changed significantly since 1993. Table 2.10 (Page 30) shows that since 1993 about half of the divers experiencing DCI reported no previous 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 seen in Table 2.11 (Page 30, bottom), about 89 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 difficult to draw any conclusion as to how physical fitness affects the likelihood or severity of DCI.

Table 2.9 *Previous Illness and Diseases of Decompression Illness Cases for the Years 1988-1996*

Problem	1996	1995	1994	1993	90-92	88-89
None	270	297	320	250	664	313
Other	57	101	81	81	203	108
GI/Abdomen	53	56	43	43	129	69
Muscl/Skel	50	49	52	59	169	83
Spine/Back	29	48	39	44	130	58
Limb/joint DCS	23	35	28	24	101	25
Asthma	14	27	21	18	49	30
Eye	13	14	17	12	25	11
Chest-lung	11	14	17	13	57	28
Chest-heart	9	17	10	15	34	17
Mental/Emotion	7	8	7	7	22	5
Neuro/Nerv	3	9	12	6	33	8
Brain	3	3	5	6	12	5
Cir/Blood	3	8	6	5	17	10
No Response	0	0	0	2	1	0
TOTALS	**545**	**686**	**658**	**585**	**1646**	**770**

Table 2.10 *Percentage of Divers Without Previous Health Problems*

Current	1996	1995	1994	1993	90-92	87-89
Frequency	270	297	320	250	664	444
Percent	56.0	50.3	56.5	49.2	46.0	47.8

Table 2.11 *Reported Physical Fitness in Injured Divers*

Sex	1996	1995	1994	1993	90-92	88-89
Male	88.0	88.4	92.6	92.9	91.2	91.0
Female	90.2	89.7	89.5	91.8	88.3	87.0
TOTAL	**88.8**	**88.8**	**91.7**	**92.5**	**90.4**	**90.0**

Table 2.12 *Medication Use in Injury Cases*

Year	Prescription Use		Nonprescription Use	
	Frequency	Percent	Frequency	Percent
1996	167	34.6	71	14.7
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

Medication Use in Injured Divers

The most common drug reported in divers with decompression illness injuries was for analgesics/non-steroidal anti-inflammatories (21 percent). Following is a breakdown of the most commonly reported medications of divers who reported DCI.

- *analgesics/non-steroidal anti-inflammatories* — *21 percent*
- *birth control medications* — *17 percent*
- *antihistamines* — *10 percent*
- *decongestants* — *10 percent*
- *psychotropics* — *8 percent*
- *antiulcer medications* — *6 percent*
- *estrogens* — *6 percent*
- *antihypertensives* — *4 percent*
- *antibiotics* — *4 percent*
- *rhinorrhea agent* — *3 percent*
- *weight loss drugs* — *2 percent*
- *migraine medications* — *2 percent*
- *anti-motion sickness medications* — *2 percent*
- *heart medications* — *1 percent*
- *insulin* — *1 percent*
- *cholesterol-lowering medications* — *1 percent*
- *thyroid medications* — *1 percent*

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 injured divers, DAN has decided not to report this category.

The most common drug reported in divers with DCI injuries was for analgesics /non-steroidal anti-inflammatories, followed by birth control medications, antihistamines and decongestants.

Table 2.13 *Percentage of Alcohol Use in 1988-1996 Injury Cases*

Time of Use	1996	1995	1994	1993	90-92	88-89
Night before	37.3	38.6	37.1	41.9	38.1	41.8
Pre-dive	0.8	1.0	1.1	1.4	1.4	1.7
Between dives	0.4	1.7	0.7	1.2	1.5	2.3
Post-dive	14.5	15.3	15.4	15.7	14.5	13.5
None	56.3	52.9	56.0	50.8	55.2	49.7
	n=483	*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.*

Table 2.14 *1996 Nausea, Hangover and Diarrhea*

Sex	Nausea	Hangover	Diarrhea
Male	7	7	7
Female	9	2	7
Totals	**16**	**9**	**14**

About 1 percent of divers reported drinking just before diving or between dives. The number of drinks consumed during these time periods is not available.

Alcohol Use In Injury Cases

Table 2.13 (top of page) shows that both the time of alcohol use and the number of divers abstaining has remained fairly constant over the reporting years.

About 1 percent of divers reported drinking just before diving or between dives. The number of drinks consumed during these time periods is not available. Because alcohol is a diuretic, it would tend to dehydrate divers. In addition, alcohol may affect performance and thinking, but there are no measures of this in DAN's database.

Nausea and hangover are two likely outcomes of excessive alcohol consumption, but only 25 divers (5.2 percent) reported either symptom on the day of the dive, as shown in Table 2.14 (immediately above). It cannot be automatically assumed, however, that all of these symptoms were alcohol-related.

Table 2.14 shows that 14 cases of pre-dive diarrhea were reported, which represents 2.9 percent of all DCI cases. Diarrhea may lead to dehydration, which is thought to be a risk factor in DCI.

The inability to conclude that drinking, hangover, nausea and diarrhea are related to DCI has nothing to do with the unknown prevalence of these in the diving population.

Summary

■ Injured male divers tend to have more years of diving experience and more total lifetime dives than injured female divers.

■ Although there are slight changes each year, the overall percentage of injury reported for each level of certification has remained relatively stable.

■ The number of females with diving experience of between six and 11 years has increased from 13.1 percent in 1995 to 23.0 percent in 1996.

Both the time of alcohol use and the number of divers abstaining has remained fairly constant over the reporting years.

To report an injury, a fatality or a near-miss in diving, call DAN's Medical Department at +1-919-684-2948

Divers Alert Network
The Peter B. Bennett Center
6 West Colony Place
Durham, NC 27705

Dive Profile / Incidents

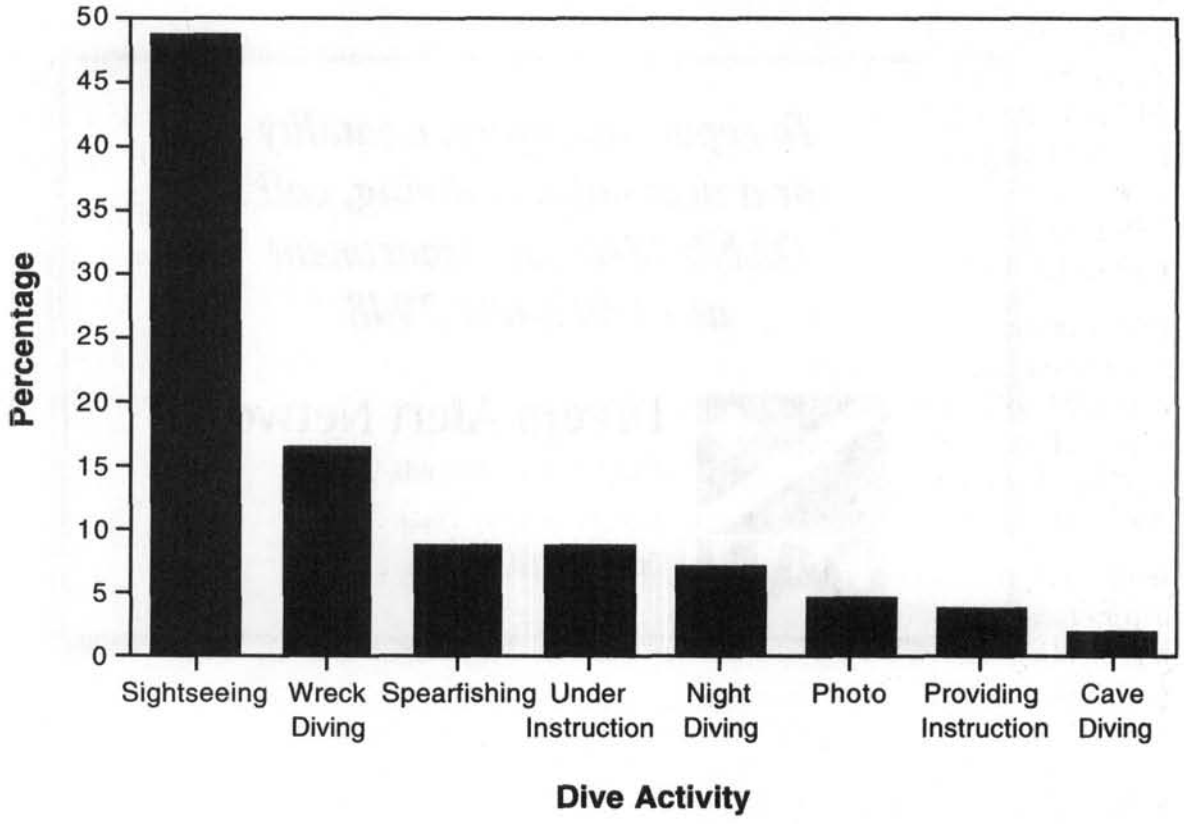
Dive Activities

A total of 48.7 percent of all injuries occurred while sightseeing; wreck diving was the second most common activity associated with diving injuries.

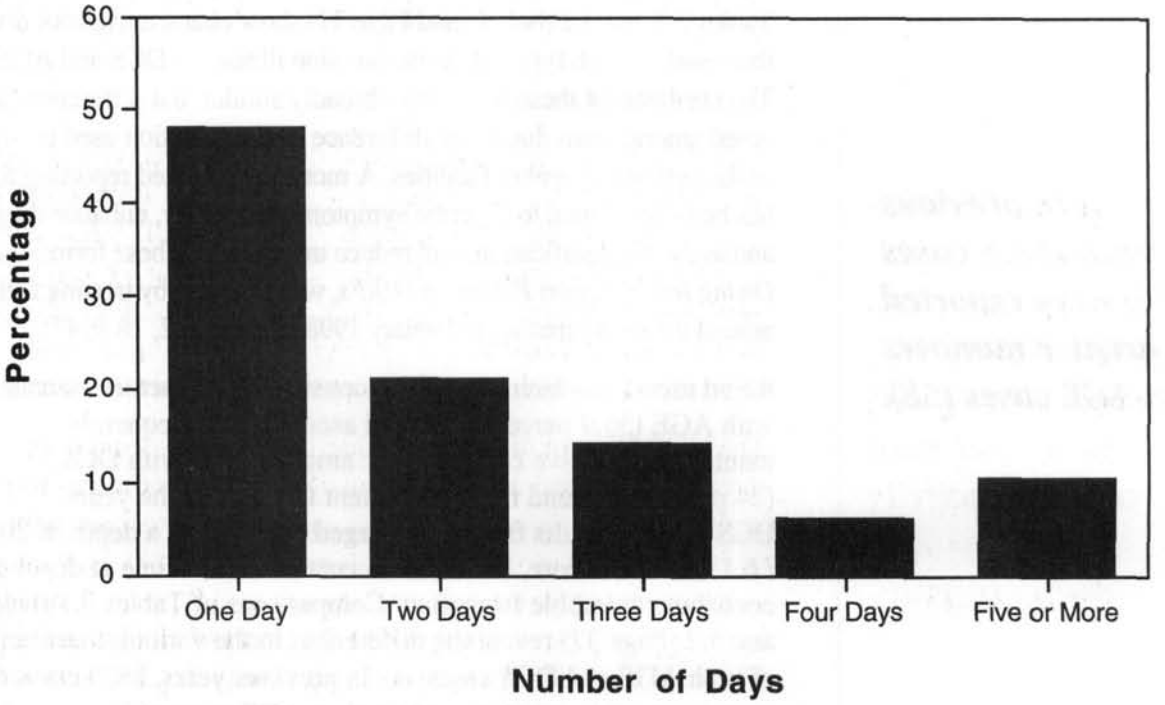
The dive profile section is meant to demonstrate the type of underwater activity being performed as well as various attributes of the dives at the time of a DCI incident. The dive profile information is limited and can only be considered in relation to the various attributes of dives recorded by DAN.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

The breakdown of diver activity has been broadly similar for the last three years. A total of 48.7 percent of all injuries occurred while sightseeing; the second most common activity associated with diving injuries was wreck diving (Graph 3.1, below). Few injuries occurred among instructors teaching scuba (3.9 percent). Students receiving instruction represented 8.7 percent of all dive activities. The incidence of DCI associated with cave diving was very low (1.9 percent) in the 1996 data.

Graph 3.1 ***Primary Dive Activity***



Graph 3.2 ***Number of Days of Continuous Diving in DCI Injuries***



Length of Dive Series

Graph 3.2 (above) shows that in 1996 almost half of all injured divers suffered their injury during a single-day dive program (48.2 percent). This percentage has slowly increased over the last few years. Further analysis of the single-day diving group revealed that 40.3 percent of the injuries occurred in divers making over 20 dives per year, and 59.7 percent had completed a dive in the last 30 days. Only 23.6 percent of those divers with less than or equal to two years of diving experience or 20 or fewer dives were injured on the first day of diving. Less frequent divers and those with a lesser amount of experience are represented in single-day DCI injuries but not at a high percentage.

One change in the dive injury data for 1996 was that 65.5 percent of all arterial gas embolism injuries occurred in single-day diving compared to 47.8 percent in 1995. Overall, more injuries occurred after the first day of diving. Approximately 52 percent of injuries were reported after two or more days of diving, and only 10.4 percent of injured divers were associated with a series of five days or more.

In the small group of divers who dived five or more days, 70 percent experienced DCS symptoms involving the nervous system. This is a higher incidence of neurological symptoms than that of the entire group and may be due to the increased nitrogen load this group experienced. Measures to decrease exposure time, such as limiting dive depth, dive times, total number of dives or simply sitting out a day of diving, may prevent DCS in this group.

One change in the dive injury data for 1996 was that 65.5 percent of all arterial gas embolism injuries occurred in single-day diving compared to 47.8 percent in 1995.

Dive Characteristics of DCS and AGE

As in previous years, DCS cases (425) were reported in greater numbers than AGE cases (58).

Tables 3.1 and 3.2 (below, and Page 37) show characteristics of dives that result in both types of decompression illness — DCS and AGE. 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 has been developed to describe symptoms accurately, enhance diagnosis and assist in classification, and reduce uncertainty. These forms, called *Diving Injury Report Forms,* or *DIRFs*, will be in use by treating facilities around the world starting in January 1998 (see Pages 2, 18 & 47).

Rapid ascent has been one of the consistent risk factors associated with AGE (56.9 percent). A rapid ascent is less frequently mentioned as a dive characteristic among divers with DCS (24 percent), a trend fairly consistent throughout the years. DCS usually results from a prolonged exposure at a depth of 20 feet / 6.1 meters or more, but rapid ascents as well as time at depth can contribute to bubble formation. Comparisons of Tables 3.1 (below) and 3.2 (Page 37) reveal the differences in the various characteristics of both AGE and DCS cases. As in previous years, DCS cases (425) were reported in greater numbers than AGE cases (58).

Table 3.1 *Characteristics of Divers with DCS*

Attribute	1996	1995	1994	1993	90-92	87-89
No Decompression	85.9	85.1	83.2	78.9	80.0	78.5*
Within Limits	80.7	97.8	86.9	**	**	**
Repeat Dive	66.4	61.2	61.8	63.6	68.2	52.9
≥ 80 fsw	64.5	72.1	71.2	70.8	64.5	74.6*
Multilevel	64.2	62.5	57.9	50.5	64.1	51.9*
Exertion	58.4	59.2	54.0	59.7	49.3	29.8
Multi Day	54.1	50.6	52.8	53.2	48.7	51.0*
Current	50.1	51.3	46.6	54.5	50.5	40.7
Single Day	45.9	49.4	47.2	46.6	51.3	53.3
Square	34.6	36.8	39.9	36.2	35.8	42.8*
Single Dive	33.6	38.8	38.2	36.2	32.6	32.7*
< 2 yr. Experience	32.0	33.8	30.1	32.2	30.9	26.1
Fatigue	28.2	32.2	30.7	29.0	34.5	34.1
Rapid Ascent	24.0	27.4	21.5	21.8	21.9	24.3
Buoyancy	15.5	14.1	12.3	11.1	11.6	13.6

**These percentages are from 1989 only.*

***The blank fields for the category "Within Limits" from 1987-1993 indicate a change in analysis methods.*

DCS Characteristics

Common traits of a classic DCS case in the DAN injury database show no-decompression repetitive dives at multiple levels. It was also most likely to involve exertion and be part of a multiday dive series and have several dives to greater than 80 feet / 24 meters. A high percentage of divers, as shown before, had more than two years of dive experience.

AGE Characteristics

The typical AGE incident from the DAN injury 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 56.9 percent of individuals with AGE claimed to have made a rapid ascent, a much higher percentage than in DCI. 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. Also more buoyancy problems were noted with AGE cases. Most AGE incidents continue to occur on the first dive of the day.

Most AGE incidents continue to occur on the first dive of the day.

Table 3.2 *Characteristics of Divers with AGE*

Attribute	1996	1995	1994	1993	90-92	87-89
No Decompression	91.4	91.3	92.7	87.8	68.1	92.3*
Within Limits	77.6	97.7	96.0	59.2	90.4	80.0
Single Dive	67.2	82.6	72.7	**	**	**
Single Day	65.5	47.8	60.0	55.1	67.9	48.6
Square	63.8	47.8	58.2	59.2	58.3	55.8*
≥ 80 fsw	58.6	58.7	47.3	44.9	49.4	46.2*
Rapid Ascent	56.9	45.7	52.7	55.1	56.3	52.0
Exertion	48.3	60.9	65.5	49.0	41.9	19.3
Current	36.2	54.3	61.8	42.9	45.5	32.6
Multilevel	36.2	52.2	40.0	22.4	41.7	35.5*
Multi Day	34.5	52.2	40.0	44.9	32.1	46.2*
Buoyancy	32.8	28.3	18.2	38.8	28.6	21.3
Repeat Dive	32.8	17.4	27.3	30.6	29.9	29.3
< 2 yr. Experience	29.3	45.7	40.0	44.9	35.7	49.3
Fatigue	24.1	8.7	21.8	22.4	13.1	29.3

**These percentages are from 1989 only.*

***The blank fields for the category "Within Limits" from 1987-1993 indicate a change in analysis methods.*

Assigning the diagnosis of AGE or DCS may be influenced by a knowledge of the dive profile and is usually taken into account in AGE cases: a short dive with minimal gas uptake weighs in favor of AGE rather than DCS.

A small group of divers were considered separately because they chose to dive without using a computer or dive tables. The category "Within Limits" represents divers who were diving within their computer or table limits. 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 the last two years' reports, each group — computer divers and table divers — is considered separately. This is the reason for the blank fields in Tables 3.1, 3.2, 3.4 and 3.5.

Assigning the diagnosis of AGE or DCS may be influenced by a knowledge of the dive profile and is usually taken into account in AGE cases: a short dive with minimal gas uptake weighs in favor of AGE rather than DCS.

Table 3.3 *Computer and Table Divers with Decompression Illness*

	Computer Users					
	1996	**1995**	**1994**	**1993**	**90-92**	**87-89**
DCS I	28.7	30.7	27.8	27.1	23.5	30.0
DCS II	64.5	64.7	66.1	66.9	69.6	62.0
AGE	6.8	4.7	6.1	6.0	6.7	8.0
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
	n = 265	*n = 337*	*n = 313*	*n = 266*	*n = 626*	*n = 251*

	Table Users					
	1996	**1995**	**1994**	**1993**	**90-92**	**87-89**
DCS I	22.6	21.6	22.9	18.6	15.4	17.5
DCS II	58.5	65.6	62.8	67.8	67.6	63.2
AGE	18.9	12.8	14.2	13.6	17.0	19.3
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
	n = 195	*n = 218*	*n = 218*	*n = 242*	*n = 735*	*n = 668*

	Neither Computer nor Table		
	1996	**1995**	**1994**
DCS I	13.0	14.3	20.0
DCS II	69.6	80.0	65.7
AGE	17.4	5.7	14.3
TOTAL	**100.0**	**100.0**	**100.0**
	n = 23	*n = 35*	*n = 35*

Methods of Dive Planning in Injured Divers

Approximately 55 percent (n=265) of the divers with DCI reported using computers, while 40 percent (n=195) reported using tables; 15 percent (n=23) used neither in planning their dives. The distribution of DCS cases between DCS I and DCS II was similar for both computer divers and table divers. This distribution has remained static since 1989.

About 19 percent of injured table divers experienced AGE, compared with 7 percent of injured computer divers. One conclusion suggested by 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) commonly used by table divers. Of the divers who did not use any method of dive planning, 70 percent had Type II DCS, 13 percent had DCS I and 17 percent were diagnosed with AGE. It would appear that using some method to determine decompression requirements may reduce the likelihood of DCS II.

Tables 3.4 and 3.5 (below and Page 40) show the attributes of both table and computer divers. By their own admission, 7.9 percent of computer divers performed dives noted to be outside the no-decompression limits for their computer. The percentage of table divers outside their tables was 18.5 percent. The 23 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 outside limits to decrease since 1993.

About 19 percent of injured table divers experienced AGE, compared with 7 percent of injured computer divers.

Table 3.4 *Attributes of Computer Divers From 1987-1996*

Attribute	1996	1995	1994	1993	90-92	87-89
Within Limits	92.1	93.8	91.1	**	**	**
Repeat Dive	84.5	77.4	82.6	82.1	69.0	63.7
Multilevel	75.6	76.0	74.6	77.7	78.8	71.4
≥ 80 fsw	73.2	77.7	78.1	79.1	73.1	86.5
Exertion	59.5	59.6	54.9	61.5	48.4	29.9
Multi Day	57.0	49.3	55.3	51.7	48.6	53.2*
Current	50.6	51.0	45.8	54.9	48.9	43.8
Single Day	43.0	50.7	44.7	48.3	51.2	50.6
Fatigue	30.3	29.4	28.5	28.3	32.5	31.0
Decompression	18.5	17.8	22.8	24.3	24.5	32.7
Outside Limits	7.9	6.2	7.0	35.1	40.9	39.4

**These percentages are from 1989 only.*
***The blank fields for the category "Within Limits" from 1987-1993 indicate a change in analysis methods.*

Table 3.5 *Attributes of Table Divers From 1987-1996*

Attribute	1996	1995	1994	1993	90-92	87-89
Within Limits	81.5	86.7	82.6	**	**	**
Repeat Dive	79.0	63.3	73.4	78.5	58.8	51.0
Exertion	61.0	61.0	56.0	57.0	49.7	27.4
≥ 80 fsw	58.5	48.6	57.3	57.0	53.7	63.4*
Multilevel	54.4	39.4	36.7	28.1	45.9	45.3*
Current	51.3	54.1	45.4	52.1	50.5	37.8
Multi Day	50.8	57.3	47.7	53.3	44.7	49.1*
Single Day	27.7	42.7	52.3	46.7	54.6	53.2
Fatigue	27.7	28.4	33.0	29.8	31.4	34.2
Outside Limits	18.5	13.3	17.4	17.8	25.6	28.7
Decompression	11.8	11.9	10.6	11.2	13.2	20.2

**These percentages are from 1989 only.*

***The blank fields for the category "Within Limits" from 1987-1993 indicate a change in analysis methods.*

In 19 percent of DCI cases, computer divers engaged in dives requiring decompression stops, whereas table divers performed decompression stops in 12 percent of DCI cases.

In about 19 percent of DCI cases, computer divers had engaged in dives requiring decompression stops, whereas table divers performed decompression stops in 12 percent of DCI cases. Multilevel dives were performed by 75.6 percent of computer divers and by 54.4 percent of table divers. This difference is expected, because dive computers favor multilevel diving in their algorithms without the bottom time limitations imposed by tables.

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

Attribute	1996	1995	1994
Multilevel	56.5	62.9	57.1
Multi Day	52.2	60.0	42.9
Exertion	52.2	48.6	62.9
Single Day	52.2	40.0	57.1
Repeat Dive	47.8	22.9	51.4
Current	43.5	42.9	88.6
≥ 80 fsw	39.1	54.3	65.7
Fatigue	26.1	37.1	28.6
Decompression	21.7	14.3	2.9
	n = 23	*n = 35*	*n = 35*

The 23 divers who used neither computers nor tables tended to follow their buddies or dive masters. These individuals dived deeper than 80 feet / 24 meters in 39.1 percent of cases, made multiday dives in approximately 52.2 percent of cases and repetitive dives in 47.8 percent (Table 3.6, Page 40).

The 1996 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 a small difference between groups in the number of divers who ran out of air (4.1 percent of table users and 0.7 percent of computer users).

DAN's 1996 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.

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 important to safe diving. Of the cases outlined in the 1996 report, 12.4 percent involved reporting equipment problems (Table 3.7, below).

Table 3.7 *1996 Equipment Problems*

Equipment	Frequency	DCS	AGE
Regulator	14	9	5
Unfamiliar Equipment	11	9	2
BC Vest	10	7	3
Other	6	5	1
Inflator Hose	5	1	4
Weight Belt	5	5	0
DC Computer	4	4	0
Dry Suit	4	2	2
Contaminated Air	1	1	0
TOTALS	**60**	**43**	**17**

The number of injuries 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 a problem with the regulator. Those divers with DCI who reported an equipment problem were most likely to have reported trouble with a regulator or buoyancy compensation vest. Over half of the divers with

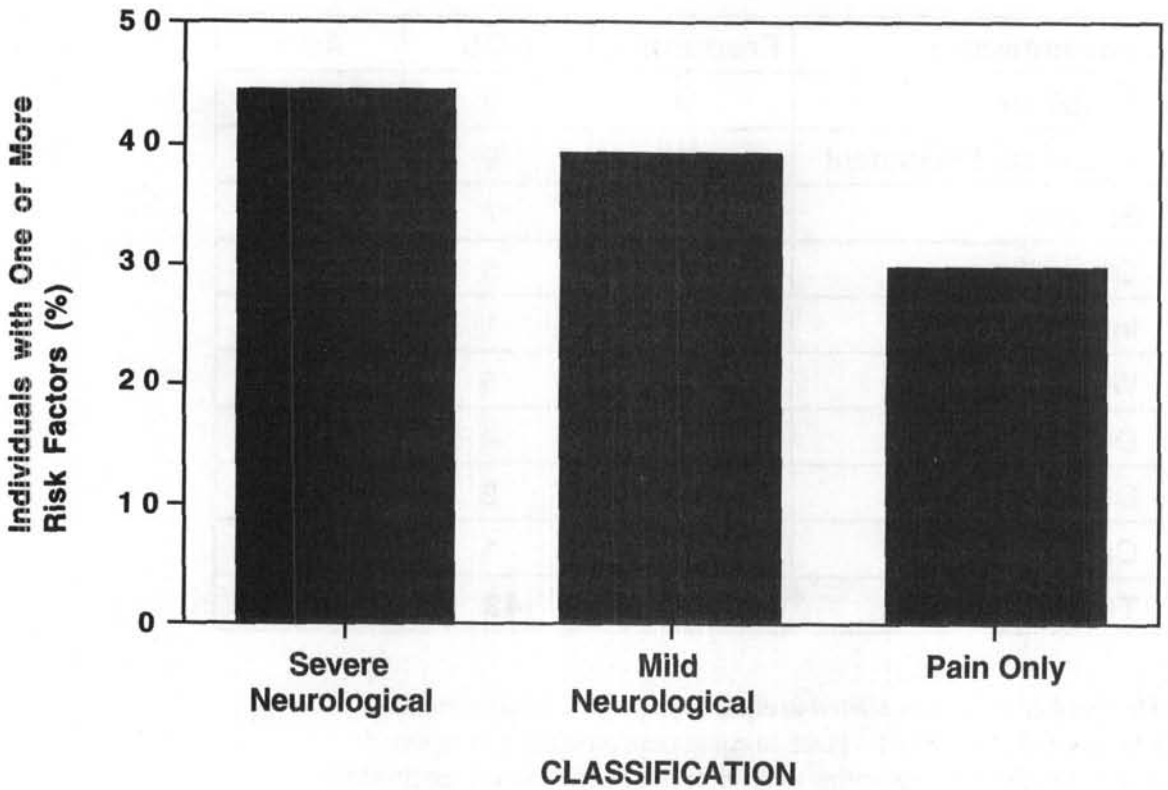
Over half of the divers with AGE and equipment difficulties reported a problem with their regulator, air supply or unfamiliarity with their gear.

AGE and equipment difficulties reported a problem with their regulator or air supply, or they reported unfamiliarity with their gear. Some divers also listed "other" problems which in some way influenced their dive profile. These included timing device failure (1), depth or pressure gauge problems (1), problems with the scuba tank (3) and problems with fins (1).

Common Risk Factors

Forty-two percent of the divers in the 1996 injury database reported experiencing one or more of the four following problems on the day of their accident: rapid ascent, buoyancy problems, equipment problems, diving outside the limits of their computer or dive tables. Graph 3.4 (below) shows the percentage of these individuals separated into the presenting symptom classification (See Table 4.1 and 4.5 in Chapter 4).

Graph 3.4 ***Common Risk Factors in Decompression Illness***



Summary

■ AGE-related cases are characterized by single-day, single-dive, square profiles, and are associated with a rapid ascent in 56.9 percent of all AGE injuries, compared to 24 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.

■ A majority of injured divers stated they stayed within the limits of their tables or computer, but 4.8 percent of all divers did not use any means of dive planning.

■ Injured divers who reported using dive computers were less likely to be diagnosed with AGE compared to DCS than divers using tables or neither method.

■ Among injured divers, computer users tend to be more experienced divers and now make up 54.9 percent of the divers reporting injuries this year.

■ Equipment problems were associated with 12.4 percent of the DCI cases. The largest percentage (23.4 percent) of these involved unfamiliarity with equipment. This suggests the importance of understanding and caring for dive equipment.

42 percent of 1996 injured divers reported one or more of the following problems:

rapid ascent, buoyancy problems, equipment problems, diving outside the limits of their computer or dive tables.

To report an injury, a fatality or a near-miss in diving, call DAN's Medical Department at +1-919-684-2948

Divers Alert Network
The Peter B. Bennett Center
6 West Colony Place
Durham, NC 27705

Symptoms of DCI

Frequency of Occurrence of Symptoms

Table 4.1's shaded totals rows show the sum of the rows it is describing. For information on the number of injured divers represented in each category see Table 4.5.

The frequency of occurrence of the symptoms of decompression illness (including all cases of both AGE and DCS) is shown in Table 4.1 (Page 45). DCI consists of different signs and symptoms developing over a period of time. As a result, the total occurrence of all symptoms (n=1,761) is greater than the total number of cases (n=483). Each diver had an average of four treatments.

As in recent years, pain was the most frequent first symptom of DCI, occurring in approximately 36 percent of the cases, while 79.9 percent of divers with DCI experienced pain at some time in their illness. Numbness also occurred at some point in 82.8 percent of DCI cases.

This year's report handles Table 4.1 differently: the rows which show totals (shaded) show the sum of the rows described. For information on the number of cases (injured divers) represented in each category (severe neurological, mild neurological and pain only/skin/ non-specific) refer to Table 4.5 (Page 48).

Several of the rows are empty because these specific symptoms did not occur as a first symptom; instead, they developed later. The "First Symptom" column shows the number of divers who recorded that one symptom appeared first out of a possible total of six. The "Total Occurrence" column shows the number of occurrences of each symptom.

The development of neurological symptoms when only pain or fatigue were present initially . . . suggests that neurological or severe symptoms might be preventable with early treatment.

For the purpose of this analysis, neurological symptoms are classified in this report 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 unmistakable motor weakness, or a vague feeling of generalized malaise. Certain symptoms such as hearing loss and ringing in the 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. Personality changes may be attributed to a number of different causes, but this symptom is too non-specific to be considered a definite symptoms of DCS as recorded in DAN's injury forms.

Eighty-two percent of divers reporting DCI developed a neurological symptom prior to treatment. Only 4.1 percent of divers reported a severe symptom first, while 25 percent reported a severe symptom later. The development of neurological symptoms when only pain or fatigue were present initially, and the progression from mild symptoms to severe ones, suggests that neurological or severe symptoms might be

Table 4.1 *1996 Most Frequent Symptoms of Decompression Illness*

			First Symptom		Total Occurrence	
			N	Percent	N	Percent
Neurological	Severe	Unconsciousness	11	2.3	18	1.0
		Paralysis	2	0.4	17	0.9
		Visual disturbance	5	1.0	31	1.8
		Difficulty walking	0	0.0	46	2.6
		Semi-consciousness	1	0.2	15	0.9
		Bowel problem	0	0.0	3	0.2
		Speech disturbance	0	0.0	11	0.6
		Bladder problem	0	0.0	2	0.1
		Convulsions	1	0.2	2	0.1
Total Severe Neurological Symptoms			**20**	**4.1**	**145**	**8.2**
Neurological	Mild	Numbness	104	21.5	400	22.7
		Dizziness	36	7.5	117	6.6
		Decreased skin sensation	2	0.4	39	2.3
		Reflex change	2	0.4	4	0.2
		Weakness	21	4.3	112	6.4
Total Mild Neurological Symptoms			**165**	**34.2**	**672**	**38.2**
Total Neurological Symptoms			**185**	**38.3**	**817**	**46.4**
Pain/skin/nonspecific		Pain	172	35.6	386	22.0
		Extreme fatigue	22	4.6	110	6.2
		Headache	38	7.9	131	7.4
		Nausea	18	3.7	88	5.0
		Itching	12	2.5	41	2.3
		Rash	6	1.0	24	1.4
		Restlessness	0	0.0	21	1.2
		Muscle twitch	2	0.4	30	1.7
		Hemoptysis	1	0.2	4	0.2
Total Pain/Skin/Nonspecific Symptoms			**271**	**56.1**	**835**	**47.4**
Ambiguous		Hearing loss	0	0.0	1	0.1
		Ringing in ears	0	0.0	3	0.2
		Personality change	2	0.4	7	0.4
Cardiorespiratory (CR)		Difficulty breathing	9	1.9	45	2.4
Other		Stiffness	3	0.6	6	0.3
		Hot/cold flashes	2	0.4	3	0.2
		Cramps	1	0.2	2	0.1
		Swelling	2	0.4	9	0.4
		Disoriented	2	0.4	15	0.9
		Motor coordination decrease	0	0.0	3	0.2
		Muscle ache/soreness	1	0.2	5	0.3
		Bleeding	1	0.2	1	0.1
		Ear blockage	1	0.2	1	0.1
		Erratic heartbeat	2	0.4	5	0.3
		Burning sensation	1	0.2	3	0.2
Total Ambiguous/CR/Other Symptoms			**27**	**5.6**	**109**	**6.2**
		Total	**483**	**100.0**	**1761**	**100.0**

Table 4.2 *Traditional Classification of DCS Symptoms*

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

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

Traditionally **decompression illness** (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 after scuba diving. DCS has been further classified into Type I, or DCS I; and Type II, or DCS II (Table 4.2, above).

Table 4.3 *Conventional Disease Diagnosis by Percentage*

Final Diagnosis	1996	1995	1994	1993	90-92	87-89
DCS-I	25.3	27.3	25.4	23.0	19.3	21.0
DCS-II	62.7	64.9	64.8	67.4	68.3	63.0
AGE	12.0	7.8	9.7	9.6	12.4	16.0
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

58 cases

The distributions of conventional diagnoses are shown in Table 4.3 (above), and has significantly changed over the years. 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.

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 has a convulsion and loses consciousness — is more likely to have AGE than DCS.

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 more likely has DCS.

In many instances, however, it is difficult 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.

Because it is still widely used, the traditional classification as assigned by the treating physician is reported in addition to the individual symptoms.

Errors in Classification

Of the 122 divers classified by the treating physician as DCS I, 62 reported neurological complaints (51 percent of divers diagnosed with DCS I, and 12.8 percent of the total injury population). Of these divers, 11 had severe symptoms, as classified by physicians at Duke University Medical Center (9 percent of divers diagnosed with DCS I and 2.3 percent of all divers).

Of the 396 divers who had neurological complaints, 15.9 percent were incorrectly classified by the person filling out the form as DCS I; of the 107 divers with severe neurological complaints, 10.3 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 it could be failure of the diver to report to the treating physician the neurological symptoms listed on the injury form.

Misdiagnosis of the severity of DCS symptoms have led to the recent emphasis on individual symptoms or "symptom clusters" as better predictors of outcome following treatment.

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 following treatment is ongoing: the classification into mild and severe symptoms outlined in Table 4.1 represents a preliminary approach. The new injury form — the Diving Injury Report Form (DIRF — see Pages 2,18 & 36) will incorporate the old classification (DCS I, DCS II, AGE) and give details on the symptoms, onset of symptoms and symptom outcome with treatment.

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 largely unchanged.

Also, there has been no change in symptom severity in the 483 cases of DCI in 1996 (Table 4.5, Page 48, top).

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

Symptom Type	DCS-I	DCS-II	AGE
Severe Neurological	11	59	37
Mild Neurological	52	217	20
Pain Only/Nonspecific	59	27	1
TOTALS	**122**	**303**	**58**

Table 4.5 *Classification by Type of Symptom (Percentage)*

Symptom Type	1996 #	1996 %	1995	1994	1993	91-92	89-90
Severe	107	22.2	24.7	27.0	25.8	32.7	27.3
Mild	288	59.6	57.6	54.2	58.5	47.3	52.6
Pain Only	88	18.2	17.6	18.7	15.7	20.0	20.1
TOTALS	**483**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
		n=483	*n=590*	*n=566*	*n=508*	*n=902*	*n=850*

95 percent of divers with AGE became symptomatic within eight hours, and 95 percent of those with DCS were symptomatic within 28 hours.

Symptom Onset Time

Symptom onset time is shown in Table 4.6 (below). 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 median onset times of DCS I and DCS II are similar. As expected, the median onset time of AGE is significantly shorter. Ninety-five percent of divers with AGE became symptomatic within eight hours, and 95 percent of those with DCS were symptomatic within approximately 28 hours.

Table 4.6 *Symptom Onset Time after Surfacing (hours): All Divers*

Classification	N	Mean	Standard Deviation	Median	95% Time*
DCS-I	122	7.4	11.3	1.0	32.0
DCS-II	303	5.7	8.6	0.7	25.0
AGE	58	0.9	14.1	0.02	8.0
All DCI	483	5.5	8.5	0.5	24.0

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

Altitude exposure can precipitate DCS symptoms after a delay,

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 4.7 (Page 49, top). Inspection of Table 4.7 shows that eliminating altitude exposure drops the median onset time for DCS I and DCS II. The time for 95 percent of all DCS I cases to develop was reduced when altitude exposures were eliminated, but the 95 percent time for DCS II was essentially unaffected.

Table 4.7 *Symptom Onset Time after Surfacing (hours) Divers with Altitude Exposure Excluded*

Classification	N	Mean	Standard Deviation	Median	95% Time*
DCS-I	82	4.3	9.4	0.5	18.0
DCS-II	225	4.5	11.2	0.5	24.0
AGE	42	0.5	1.6	0.02	1.5
All DCI	349	3.9	10.3	0.5	21.0

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

Table 4.8 *Percentage of Divers with Decompression Illness Symptoms Prior to Last Dive*

Sex	1996	1995	1994	1993	90-92	88-89
Male	18.1	16.1	17.6	17.7	16.9	13.4
Female	14.9	18.9	20.4	26.6	36.0	26.0
TOTAL	**17.0**	**16.9**	**18.4**	**20.5**	**22.1**	**16.5**
	n=483	*n=590*	*n=566*	*n=508*	*n=1,361*	*n=649*

Symptoms Prior to Last Dive

Eighty-two divers — 17 percent of all divers; 18.1 percent of males, 14.9 percent of females — reported having experienced symptoms prior to their last dive (Table 4.8, above).

The proportion of divers continuing to dive after symptom onset is similar to that in previous years. A distribution of the type of symptoms experienced prior to the last dive is shown in Table 4.9 (below).

17 percent of all divers with DCI reported having experienced symptoms prior to their last dive.

Table 4.9 *Symptom Classification of Divers Experiencing Symptoms Prior to Last Dive*

Symptom Category	Number	Percent*
Severe Neurological	17	3.5
Mild Neurological	50	10.4
Pain/Skin/Nonspecific	15	3.1
TOTAL	**82**	**17.0**

** Percentages are of the total injury population.*

17 individuals with DCI continued to dive with severe neurological symptoms.

Seventeen individuals continued to dive with severe neurological symptoms. Two individuals had numbness in both legs, which caused them to have difficulty walking but both dived again 24 hours later.

One individual made two more dives after first experiencing symptoms and then waited eight hours to call for assistance. This individual was treated 24 hours later with complete relief of symptoms.

The other individual dived for five more days, making an additional eight dives. Three days after the end of the dive series he was treated with IV fluids and oxygen at the hospital plus one Treatment Table 6, with complete relief of symptoms.

One diver had facial numbness and a speech disturbance but continued to make two more dives 24 hours later. He received oxygen at the hospital and had multiple treatments four days after the dive series and left the hospital facility with complete relief.

One diver was having difficulty breathing but made another dive. The individual was treated with oxygen and recompression five hours later. This person was diagnosed with arterial gas embolism and had residual neurological symptoms for 10 days.

Another diver was light-headed and coughing up blood but decided to make two more dives approximately one hour later. Treatment was 11 hours later and consisted of oxygen and recompression therapy. This individual had residual neurological symptoms for three days.

The 12 other individuals of the 17 with severe neurological symptoms continued to dive with symptoms ranging from headache to joint pain to back/abdomen pain, but all developed severe neurological signs after the dive series ended.

Table 4.10 *Previous Injury Classification by Present Diagnosis*

	Classification of the Previous Injury					
Present Diagnosis	**Possible DCS**	**DCS**	**Pulmonary Barotrauma**	**AGE**	**None**	**TOTALS**
DCS-I	8	5	0	1	108	122
DCS-II	8	25	0	1	269	303
AGE	2	1	0	0	55	58
TOTALS	**18**	**31**	**0**	**2**	**432**	**483**

Previous Decompression Illness

Table 4.10 (Page 50, bottom) shows data relating to divers who had suffered a previous incident of DCI. Table 4.11 (below) shows data relating to the severity of symptoms. Similar to previous years, both show that, of the 483 cases presented here, a total of 51 (10.6 percent) divers had previously experienced either possible DCS, actual DCS or pulmonary barotrauma. Divers with previous injuries may possibly be ones with more experience and hence at an inherently higher risk because of increased exposure to the environment (more dives, more total dives).

Divers with previous injuries may possibly be at an inherently higher risk because of increased exposure to the environment.

Divers who reported previous DCS (N = 31) had logged more dives (median number 200) than those who had not reported such history (median 44 dives), and six of these divers reported having logged 1,000 or more dives. Only 12 of 31 (38.7 percent) of divers with previous DCS had either rapid ascent, buoyancy or equipment problems or were not within table or computer limits — lower than the 45 percent in the entire 1996 injury population. All individuals with previous DCI followed a table or used a dive computer for the dive immediately preceding the onset of symptoms.

Table 4.11 *Classification of the Previous Accident by Presenting Symptoms*

	Classification of the Previous Injury					
Previous Symptoms	**Possible DCS**	**DCS**	**Pulmonary Barotrauma**	**AGE**	**None**	**TOTALS**
Severe Neurological	6	3	0	1	97	107
Mild Neurological	7	24	0	1	256	288
Pain/Skin/ Nonspecific	5	4	0	0	79	88
TOTALS	**18**	**31**	**0**	**2**	**432**	**483**

Summary

In one-third of DCI cases, pain was the first symptom, while 80 percent of divers with DCI experienced pain at some point in their illness.

The second most common symptom was numbness and occurred at some time in over 80 percent of DCI cases.

- In one-third of DCI cases, pain was the first (initial) symptom, while 80 percent of divers with DCI experienced pain at some point in their illness.
- The second most common symptom was numbness (one-fifth of cases), which occurred at some time in over 80 percent of cases.
- A little less than one-quarter of all DCI cases had severe neurological symptoms (altered consciousness, paralysis, visual symptoms, bowel/bladder problems, gait abnormalities or convulsions).
- The traditional classification scheme (DCS I, DCS II, AGE) is frequently applied incorrectly by the reporting physicians. Almost 50 percent of 122 divers classified as DCS I reported neurological symptoms to DAN on the Diving Accident Reporting Form (DARF).
- The first symptoms developed within 30 minutes of surfacing in half of the cases. In 95 percent of these cases, DCI symptoms developed within 24 hours.
- Seventeen percent of divers with DCI reported having experienced symptoms before their last dive; nine reported severe neurological symptoms, supporting the need for more education regarding the signs and symptoms of DCI.

To report an injury, a fatality or a near-miss in diving, call DAN's Medical Department at +1-919-684-2948

Divers Alert Network
The Peter B. Bennett Center
6 West Colony Place
Durham, NC 27705

Treatment

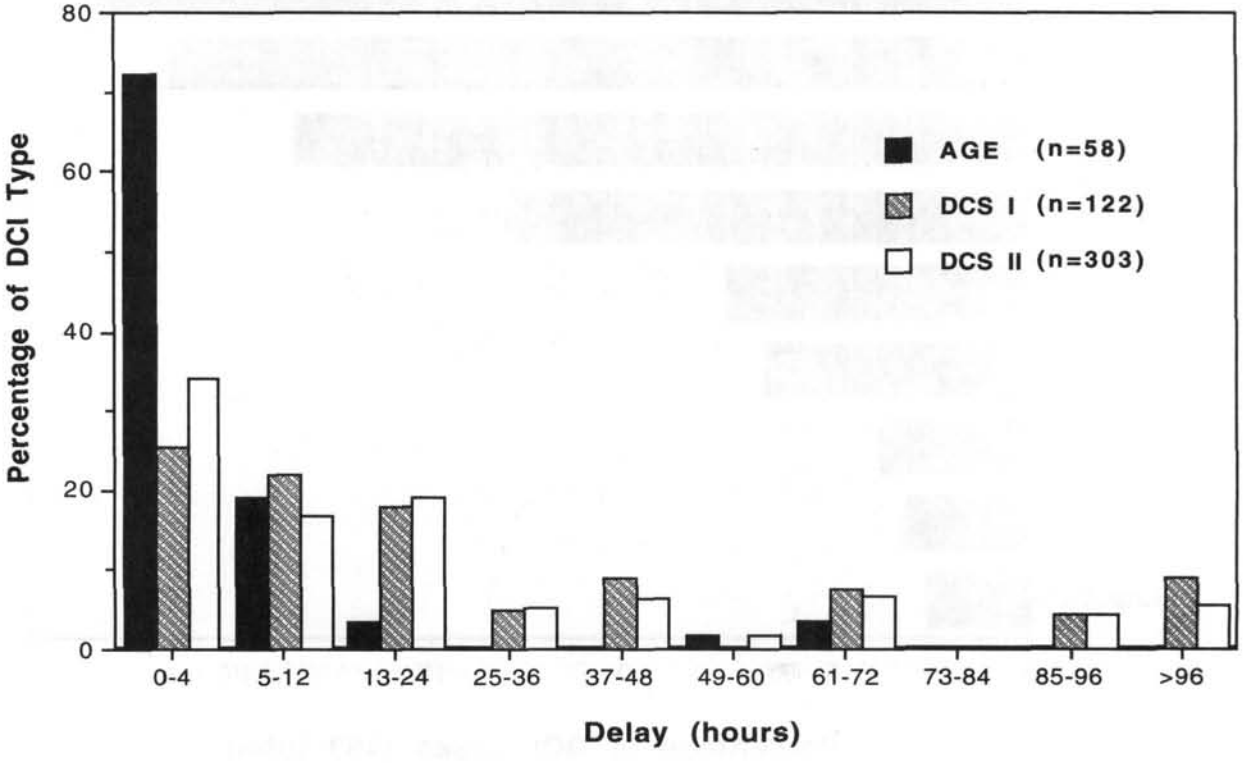
The ultimate outcome for divers experiencing decompression illness depends on early recognition of symptoms, prompt diagnosis with early institution of appropriate first aid and definitive treatment. The following data summarizes the treatment information submitted to DAN in 1996 for the 483 reported cases of decompression illness.

Delaying the Call for Assistance

The data presented in Graph 5.1 are similar to that of previous years. As might be expected, the vast majority of calls within the first four hours were from divers suffering from AGE. In 1996, this number reached 72 percent, a slight decrease from the 80 percent in 1995.

In contrast, only 31.5 percent of all DCS cases reporting to DAN in 1996 called for assistance in the first four hours of symptom onset (DCS I n=31; DCS II n=103, out of 425 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 17 percent of DCI cases who waited more than 48 hours prior to seeking assistance. Although this could be in part related to symptom denial, it also could be partially due to lack of recognition of symptoms.

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



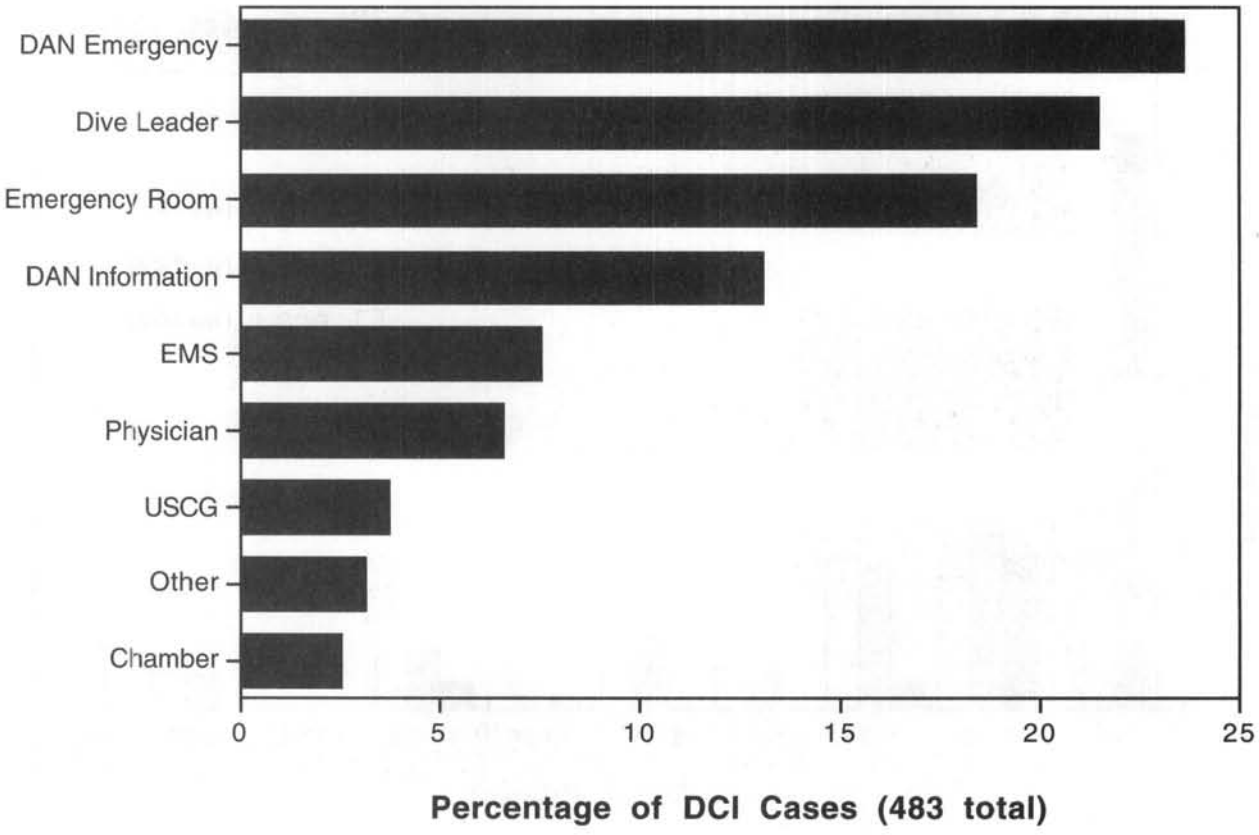
Initial EMS referrals exceeded physician referrals in 1996, whereas in 1995 there were almost twice as many physician- as EMS referrals. Also, this year 2 percent of the injury cases first contacted a recompression facility directly.

Thirty-six percent of all DCI cases in the 1996 database initially contacted DAN, either through the Diving Emergency Hotline or through the Medical Information Line (Graph 5.2, below). An additional 27 percent of all cases first contacted a local physician, hospital, emergency department or recompression facility for assistance and/or evaluation.

Twenty-two percent of reported DCI cases initially sought advice from their dive instructors or dive guides. 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 the closest appropriate physician and/or recompression facility.

Eleven percent of all reported cases received initial assistance from the U.S. Coast Guard or emergency medical services (EMS), while the remaining four percent utilized the services of airport and hotel personnel, insurance companies, friends and the U.S. military. Of note is that initial EMS referrals exceeded physician referrals in 1996, whereas in 1995 there were almost twice as many physician referrals as EMS referrals. Also, this year 2 percent of the injury cases first contacted a recompression facility directly.

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



Initial Contacts to DAN

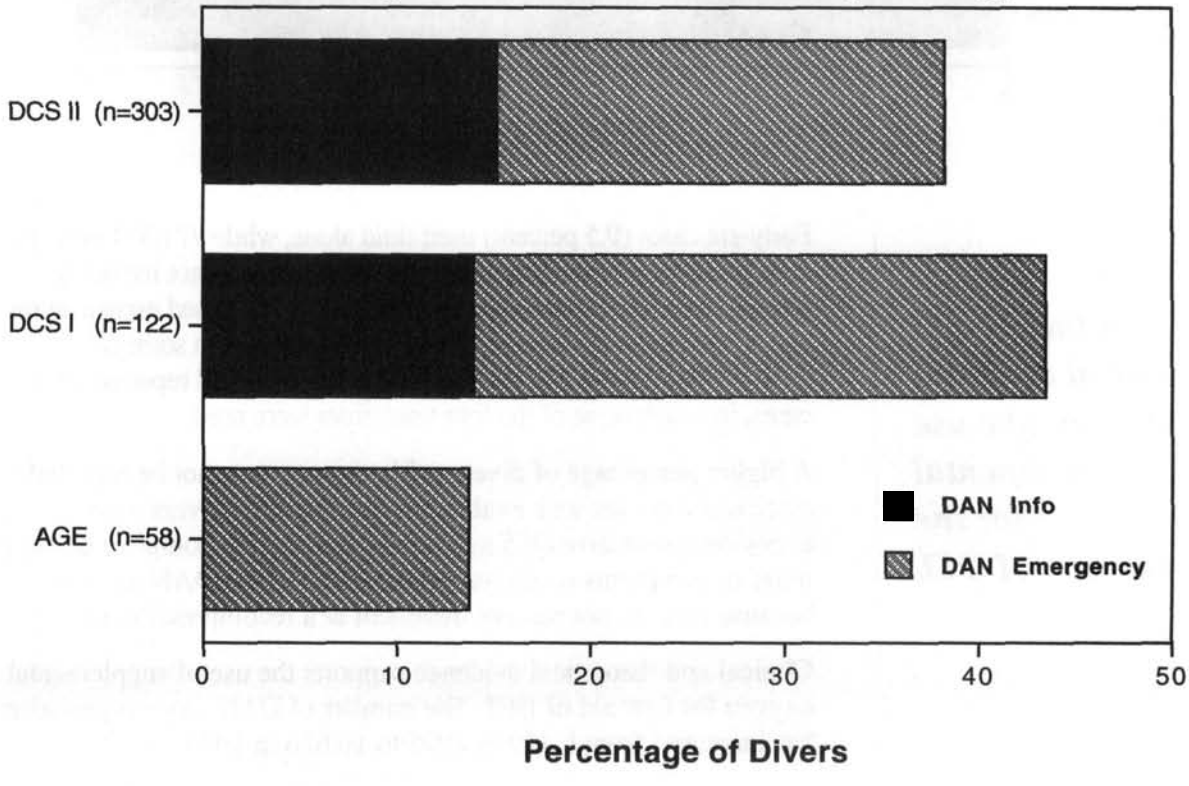
Of the 177 divers who utilized DAN as the initial contact, 169 did so for assistance with either DCS I (n=53) or DCS II (n=116). Graph 5.3 (below) shows the breakdown of these contacts, indicating whether they utilized the emergency or non-emergency telephone lines. The percentage of divers in 1996 who utilized the non-emergency information line for consultation on DCS II remained at 40 percent (n=46 out of 116 DCS II cases) when compared to 1995 data. This continues to be a disturbing statistic given the importance of prompt recognition and treatment of cases of severe neurological DCS.

Only eight of the 58 (13.8 percent) who reported AGE cases in 1996 utilized DAN as the initial point of contact for assistance. All eight cases 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 have been 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 DCI-related.

Of the 50 other divers who were treated for AGE, the point of initial contact varied. Some (n=15) reported directly to a hospital emergency room, while some of the injuries prompted an initial contact with EMS (n=13), and others reported their symptoms to their instructor (n=13). In six cases, the United States Coast Guard was the first point of contact, two others called a local physician and one was listed as other.

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

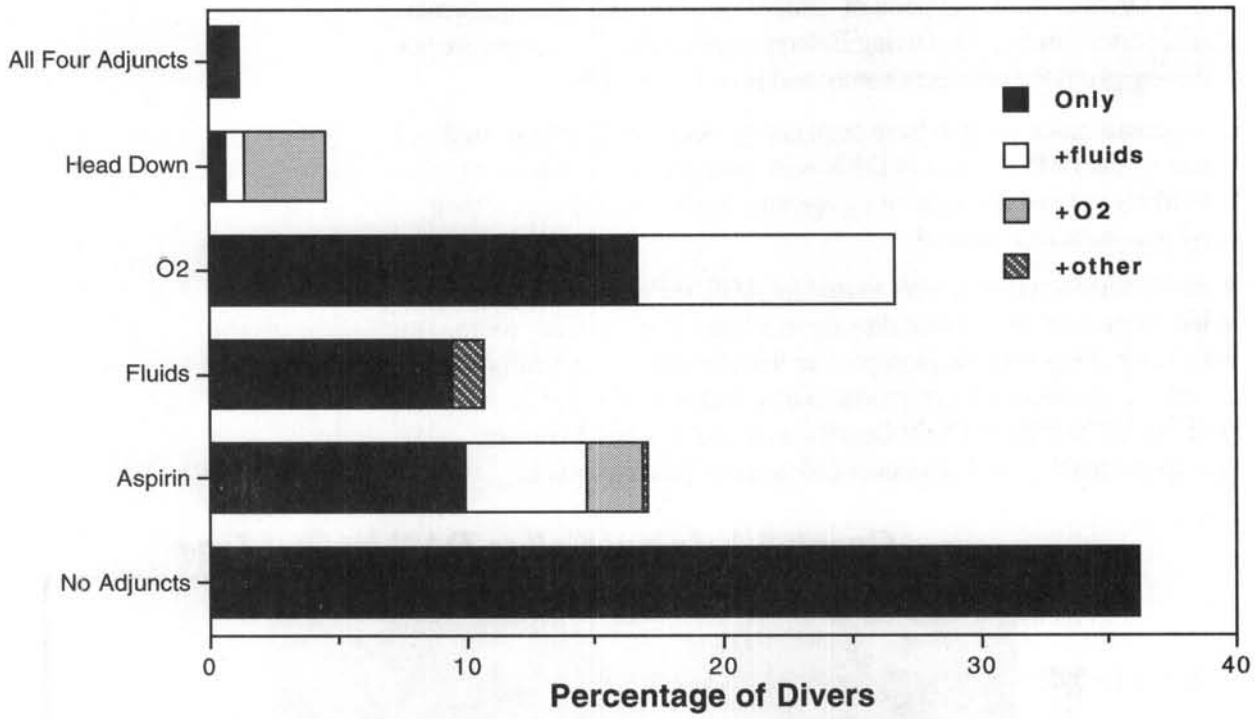


The Use of Oxygen First Aid and Other Adjuncts

36 percent of 1996 DCI cases utilized oxygen for first aid — up 4 percent from 1995.

A total of 308 (63.8 percent) of all DCI cases reported to DAN in 1996 utilized one or more of four adjuncts in first aid (oxygen, oral fluids, head-down position or aspirin). Of the 483 DCI cases, 175 (36 percent) utilized oxygen alone or in combination with other treatment modalities for first aid (Graph 5.4, below) — up 4 percent from 1995. Eighty cases (16.6 percent) utilized oxygen alone, while only 49 (10 percent) used fluid and emergency oxygen.

Graph 5.4 ***First Aid Used***



Clinical and theoretical evidence supports the use of supplemental oxygen for the treatment of DCI.

Forty-six cases (9.5 percent) used fluid alone, while 97 (20.1 percent) used fluids in combination with other interventions (not including oxygen) as a first aid measure. Ten percent (n=48) used aspirin alone, and 45 (9.3 percent) used aspirin in combination with some other therapy. There were 175 cases (36 percent), out of all reported DCI cases, in which none of the four treatments were used.

A higher percentage of divers using oxygen may not be reported since some do not seek evaluation and therapy. Divers who experience post-dive DCI symptoms and receive complete or partial relief of symptoms using oxygen never enter the DAN database because they do not receive treatment at a recompression facility.

Clinical and theoretical evidence supports the use of supplemental oxygen for first aid of DCI. The number of DAN oxygen providers has increased from 9,419 in 1995 to 10,626 in 1996.

Table 5.1 *Emergency Oxygen: 1994-1996*

Diagnosis	1996 (n=483)			1995 (n=590)			1994 (n=566)		
	Total #	O2 Use	%	Total #	O2 Use	%	Total #	O2 Use	%
AGE	58	52	90.0	46	38	82.6	55	44	80.0
DCS-I	122	60	49.2	161	67	41.6	144	79	54.9
Severe Neurological	59	41	68.3	118	81	68.6	153	64	41.8
Mild Neurological	244	156	64.2	265	141	53.2	214	153	71.5
TOTALS	**483**	**309**	**64.0**	**590**	**327**	**55.4**	**566**	**340**	**60.1**

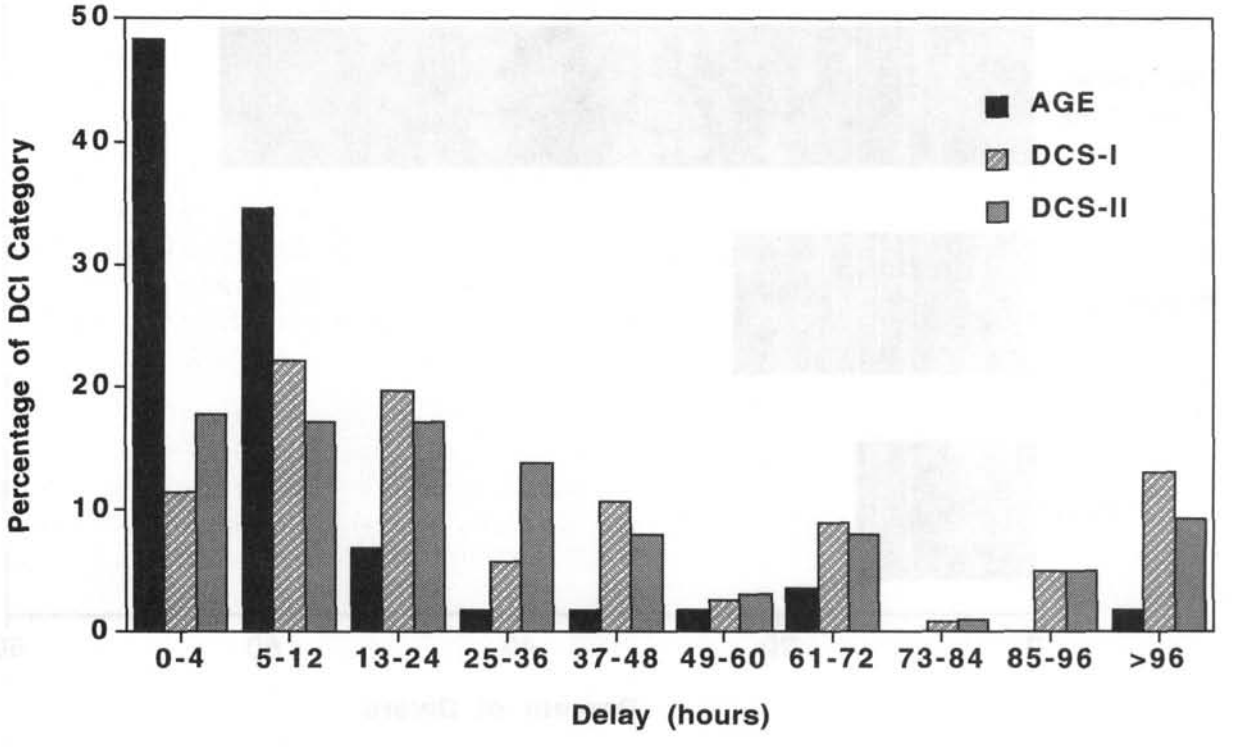
The distribution of emergency oxygen use is listed in Table 5.1 (above). The efficacy of emergency oxygen use in conjunction with hyperbaric recompression therapy is discussed later and shown in Graphs 5.7 and 5.8 (Pages 59-60). Unfortunately, DAN does not have data on the duration of oxygen breathing, the type of delivery system used, or the delay to starting oxygen after symptoms have begun. All three factors may be important in treating DCI and the final outcome.

Delay to Recompression

Although significant variability from the time of symptom onset to beginning of recompression therapy continues (see Graph 5.5 below),

Early recompression treatment is crucial, and education may increase the percentage treated in less than 12 hours.

Graph 5.5 *Delay from First Symptom Onset to Recompression Therapy*



28 of the 58 cases of AGE (48.3 percent) received hyperbaric therapy within four hours of symptom onset, while 83 percent (n=48) were recompressed within 12 hours. These percentages are likely related to improved diver education in symptom recognition and emergency management, together with improved emergency evacuation procedures. Early treatment is crucial, and education may increase the percentage treated in less than 12 hours.

The delay to treatment for cases of DCS I and DCS II was similar to previous years' reports.

The delay to treatment for cases of DCS I and DCS II was similar to previous years' reports, with 11.5 percent and 17.8 percent respectively (14 of 122 DCS-I, and 54 of 303 DCS-II), being treated within four hours of symptom onset; and 33.6 percent and 35 percent (41 of 122 and 106 of 303 DCS-II) being treated within 12 hours.

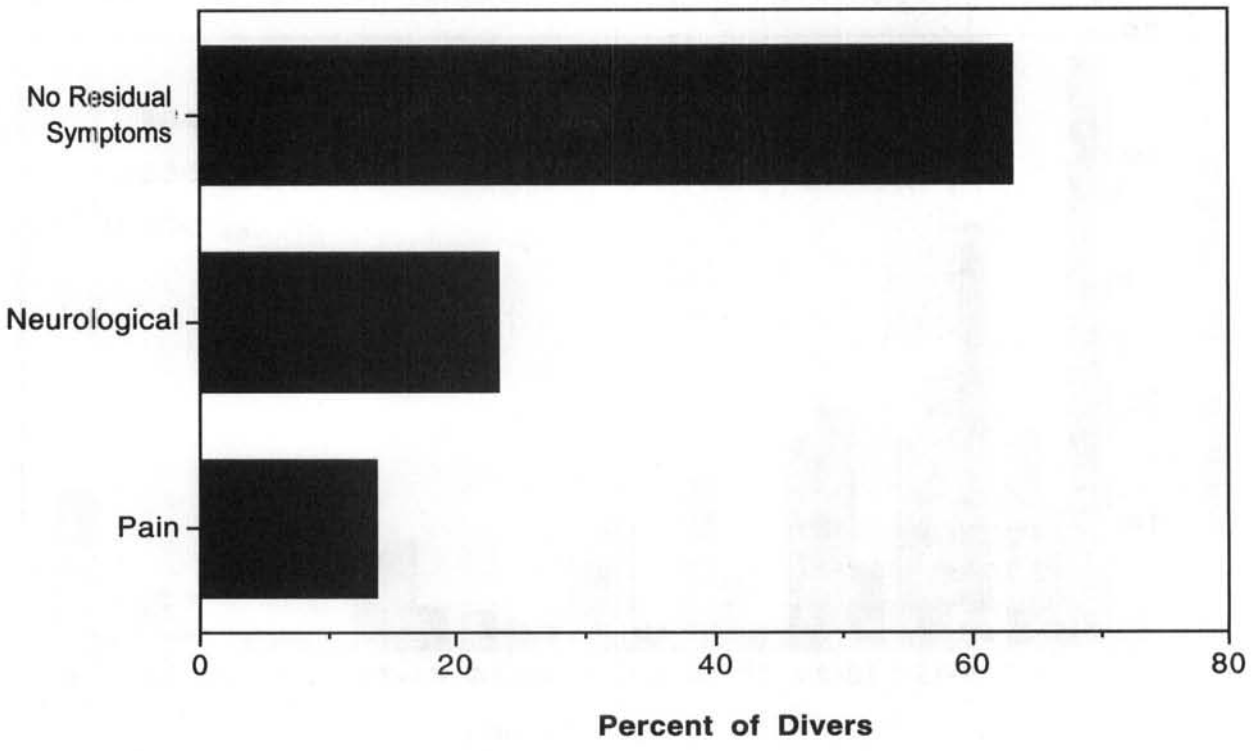
The causes for delay to treatment can include a variety of reasons and include:

- 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
- waiting to see if symptoms spontaneously resolve
- early relief using oxygen first aid followed by a return of symptoms

Effectiveness of Recompression Treatments

Graph 5.6 (below) shows that recompression treatments for the 1996 DCI cases reported to DAN resulted in complete resolution of symptoms at the end of all hyperbaric therapy greater than half of the time (63 percent, 305 of 483 cases).

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



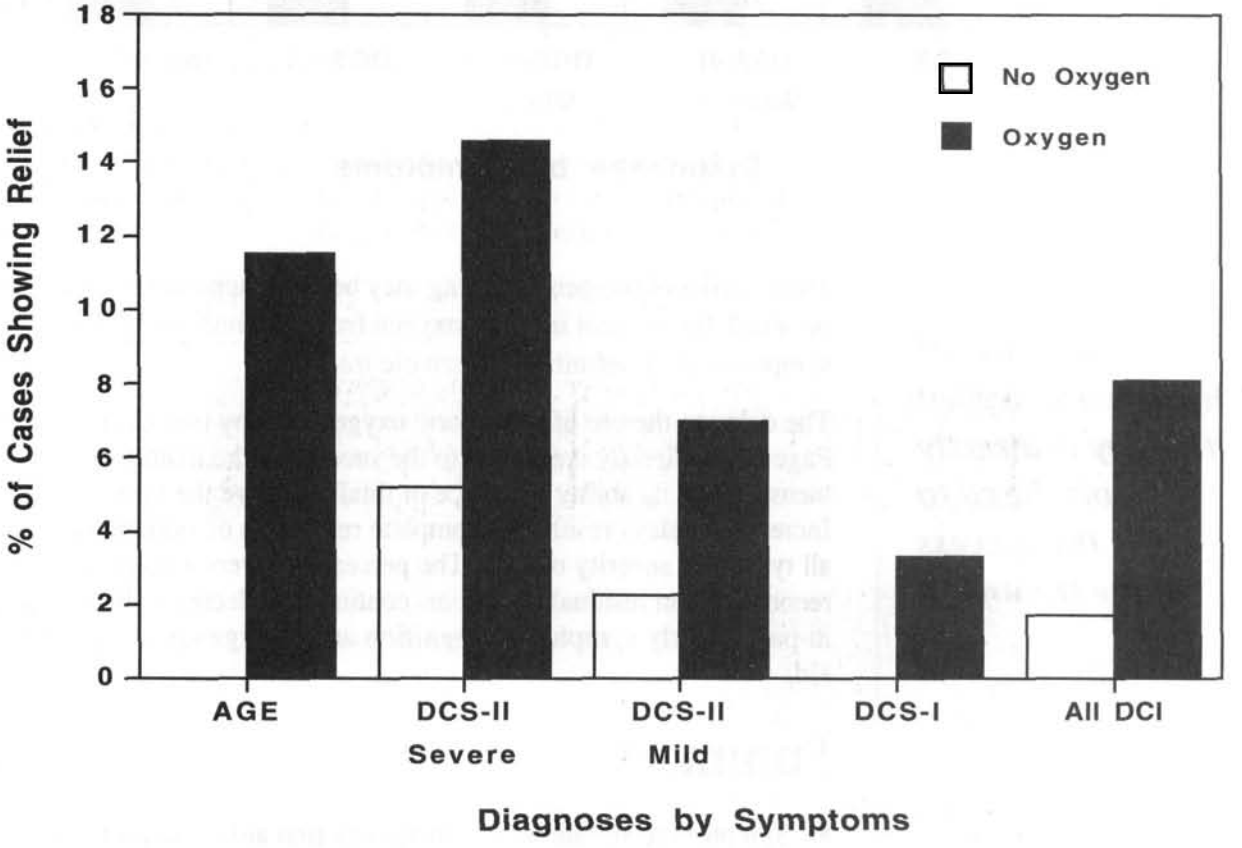
Of the divers with residual symptoms, 23 percent had residual neurological symptoms, while 13.7 percent had pain-only residuals (112 and 66 of 483 cases). These data are consistent with those reported in past years.

Graphs 5.7 and 5.8 (below and Page 60) show the improvement in overall symptom-free outcome for those divers who receive emergency oxygen first aid.

Eight percent of the reported DCI cases in 1996 were symptom-free following surface oxygen before recompression therapy. In addition, 2 percent reported being symptom-free *without* oxygen before recompression. All divers received recompression therapy even if they were asymptomatic upon reaching the chamber. Sixty-five percent of all DCI cases were symptom-free following all hyperbaric treatments (some received multiple treatments) when the divers were given oxygen first aid, whereas 60 percent of the recompressed divers not treated with emergency oxygen were symptom-free.

65 percent of all DCI cases were symptom-free following all hyperbaric treatments when the divers were given oxygen first aid.

Graph 5.7 ***Relief of All Symptoms by Oxygen Before Recompression***

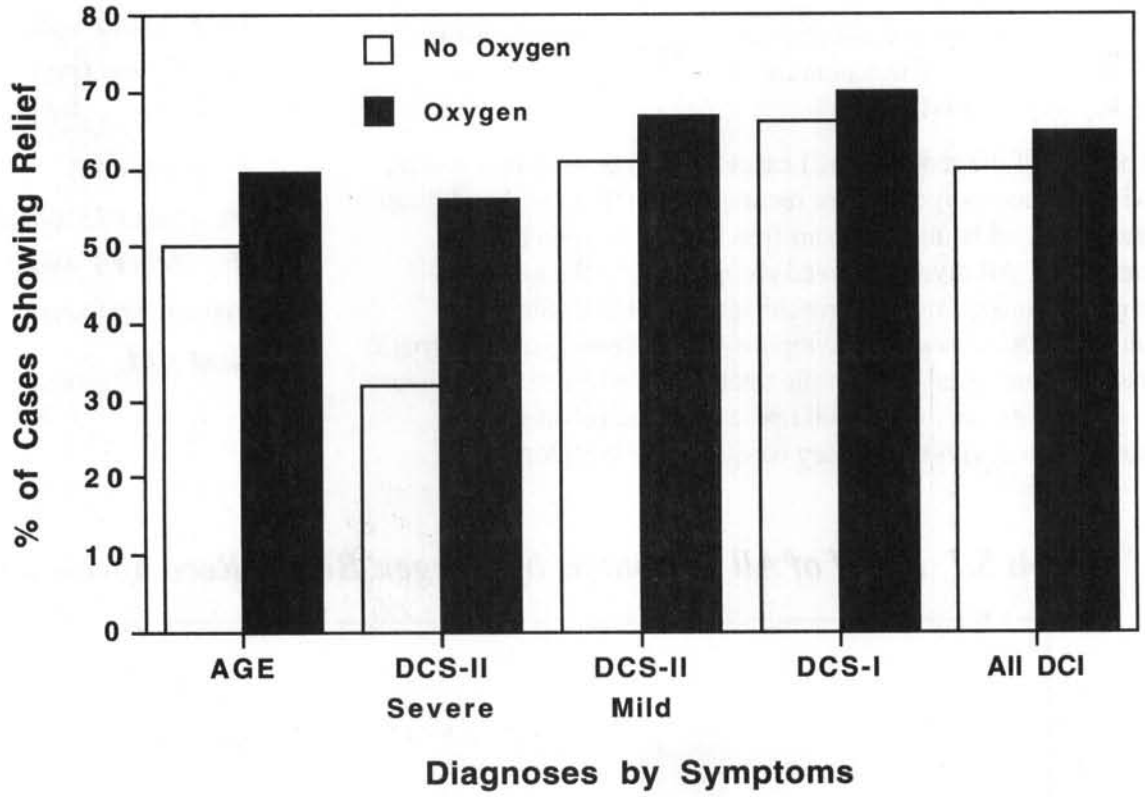


DEFINITIONS

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 45) for a list of all symptoms.

Graph 5.8 ***Relief of All Symptoms by Oxygen After All Recompression***



The use of hyperbaric oxygen therapy is directly correlated to the success of the treatment

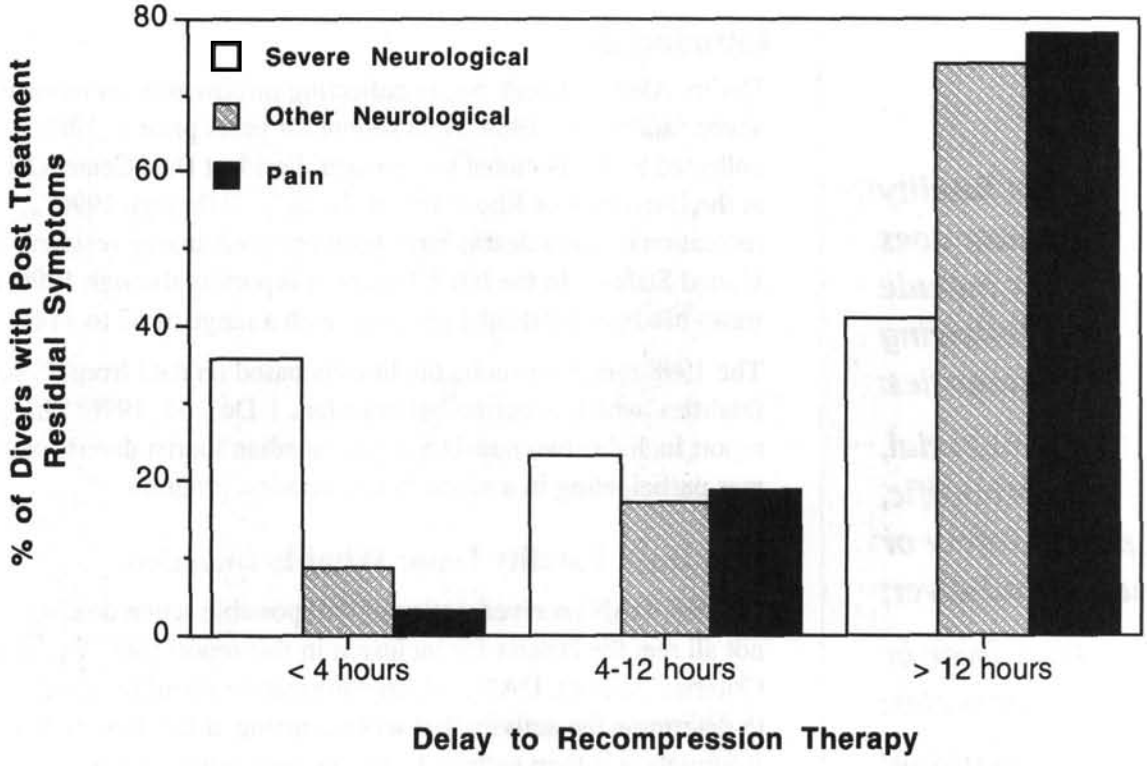
The benefits of oxygen breathing may be more apparent if all divers breathed 100 percent inspired oxygen from the time of onset of symptoms until definitive hyperbaric treatment.

The delay to the use of hyperbaric oxygen therapy (see Graph 5.9, Page 61) 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 oxygen first aid.

Summary

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

Graph 5.9 *Percentage of Divers with Post-Recompression Residual Symptoms Related to Delay to Recompression Therapy*



■ The greater recognition of symptoms of AGE, perhaps due to their severity and acute nature, results in more prompt treatment.

■ Education in the recognition of decompression illness may improve the response time to provide emergency oxygen first aid and appropriate recompression treatment. Education of divers and instructors in the recognition of symptoms of DCI is critical. The rising percentage of divers initially contacting dive instructors supports the need for education and awareness by this group.

■ The number of divers who recognize the symptoms of DCI and begin immediate first aid with emergency oxygen continues to increase each year.

■ Thirty-six percent of all reported DCI cases received emergency oxygen first aid. An increasing number of divers stop the use of 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 signs or symptoms on examination.

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

Symptom recognition and emergency first aid of suspected DCI is important in the ultimate resolution of decompression illness.

Scuba Fatalities

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. From 1970 through 1996, 2,771 recreational scuba deaths have been reported among residents of the United States.* In the last 10 years of reporting through 1996, the mean has been 90 deaths per year, with a range of 67 to 114.

The 1998 report on scuba fatalities is based on data from 85 scuba fatalities, which occurred between Jan. 1-Dec. 31, 1996. This year's report includes two non-U.S./non-Canadian tourist divers, one who was participating in a scuba familiarization program.

1996 DAN Fatality Data: What Is Included

In 1996, DAN received notice of 140 possible scuba deaths, but not all met the criteria for inclusion in this report (see "Exclusion Criteria," below). DAN collects information on all reported fatalities to determine the activity that was occurring at the time of death. Information is then gathered only on cases pertaining to recreational, personal-task and technical scuba diving fatalities. Information is gathered on those fatalities involving U.S. residents worldwide and foreign nationals in U.S. waters. Uncertified divers who attempt scuba for recreational purposes are also included.

Exclusion Criteria

Several factors are used to exclude a case from being followed up and entered into the fatality database. The DAN fatality database does not include any fatality which falls into the following categories:

- commercial, scientific, public safety or occupational diver;
- free-diver or snorkeler;
- foreign national not diving in U.S. waters;
- non-diving related accident, such as a boating accident.

Of the 140 deaths reported in 1996, 55 were excluded: 11 were commercial divers, 19 were free-divers, 20 were foreign nationals, and five were non-diving-related.

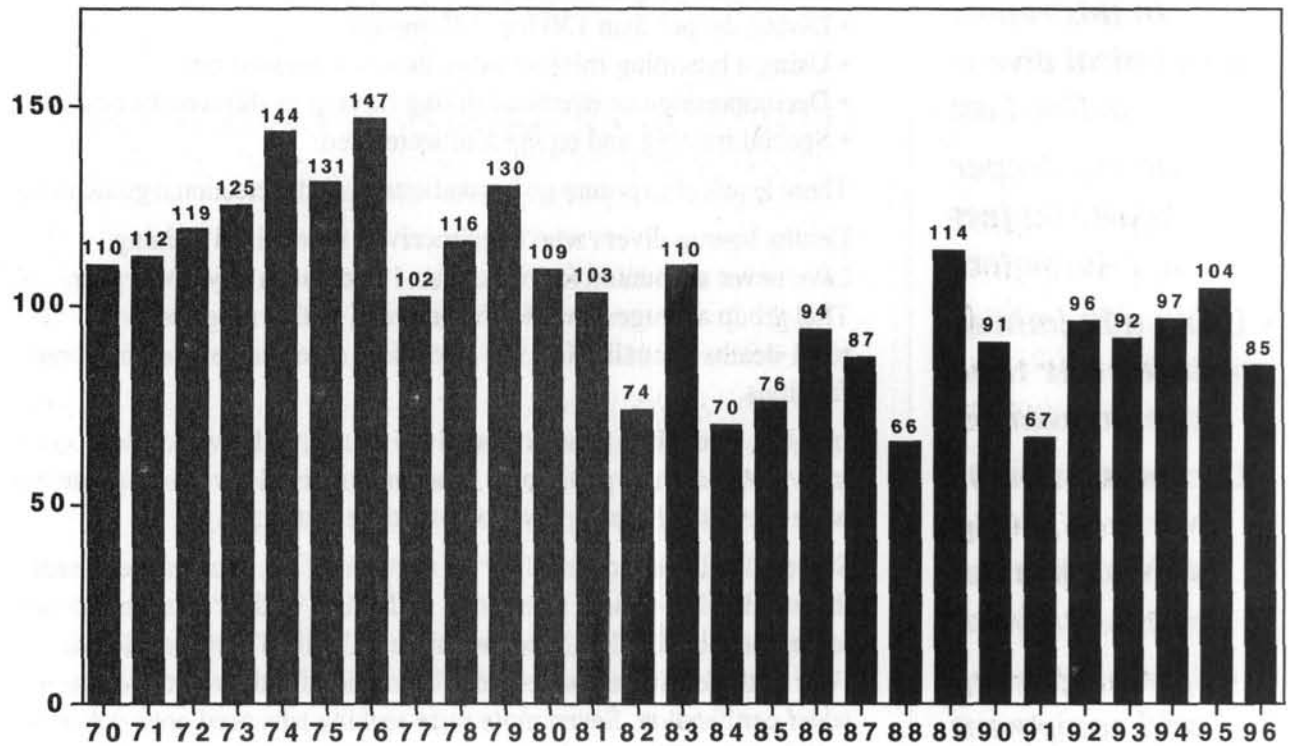
All diver fatalities that pass through the exclusion criteria, including uncertified divers, are included in the analysis of scuba fatality data in this report.

DAN's fatality database does not include the following categories:

- ***commercial, scientific, public safety or occupational diver;***
- ***free-diver or snorkeler;***
- ***foreign national not diving in U.S. waters;***
- ***non-diving-related accident, such as a boating accident.***

** NOTE: There is a correction concerning this figure and the cumulative years in last year's report, Page 64. It read: "Over the past 25 years, 2,786 recreational scuba deaths have been reported among residents of the United States." The figure should have been **2,686** deaths over the past **26** years, reflecting the time period 1970 through 1995.*

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



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.

Breakdown of Fatalities: Year, Certification, Type of Dive

Graph 6.2 (Page 64) 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 69 deaths in 1996. This is slightly lower than the 79 reported in 1995 .

The number of certified recreational divers who were attempting to make a dive they were not qualified for ranges between five and 15, with an average of 10 deaths per year. Based on certification level and advanced training information contained in the reports sent to DAN, these individuals were performing dives that are considered technical diving and require special training and equipment that they did not possess. The largest number of these deaths involved attempts at deep diving, wreck penetration or cave diving. In 1996, this group represented 10 fatalities and are classified as "Recreational/ Technical Divers" on Graph 6.2 (Page 64).

Deaths among divers who reportedly dived within the limits of their certification and experience accounted for 71 deaths in 1996.

Eight fatalities involved divers attempting dives for which they were not trained.

In this report a technical dive is defined as:

- ***Diving deeper than 130 feet / 40 meters***
- ***Using a breathing mixture other than compressed air***
- ***Decompression or overhead diving (diving in shipwrecks or caves)***
- ***Special training and equipment were used.***

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

- Diving deeper than 130 feet / 40 meters;
- Using a breathing mixture other than compressed air;
- Decompression or overhead diving (diving in shipwrecks or caves);
- Special training and equipment were used.

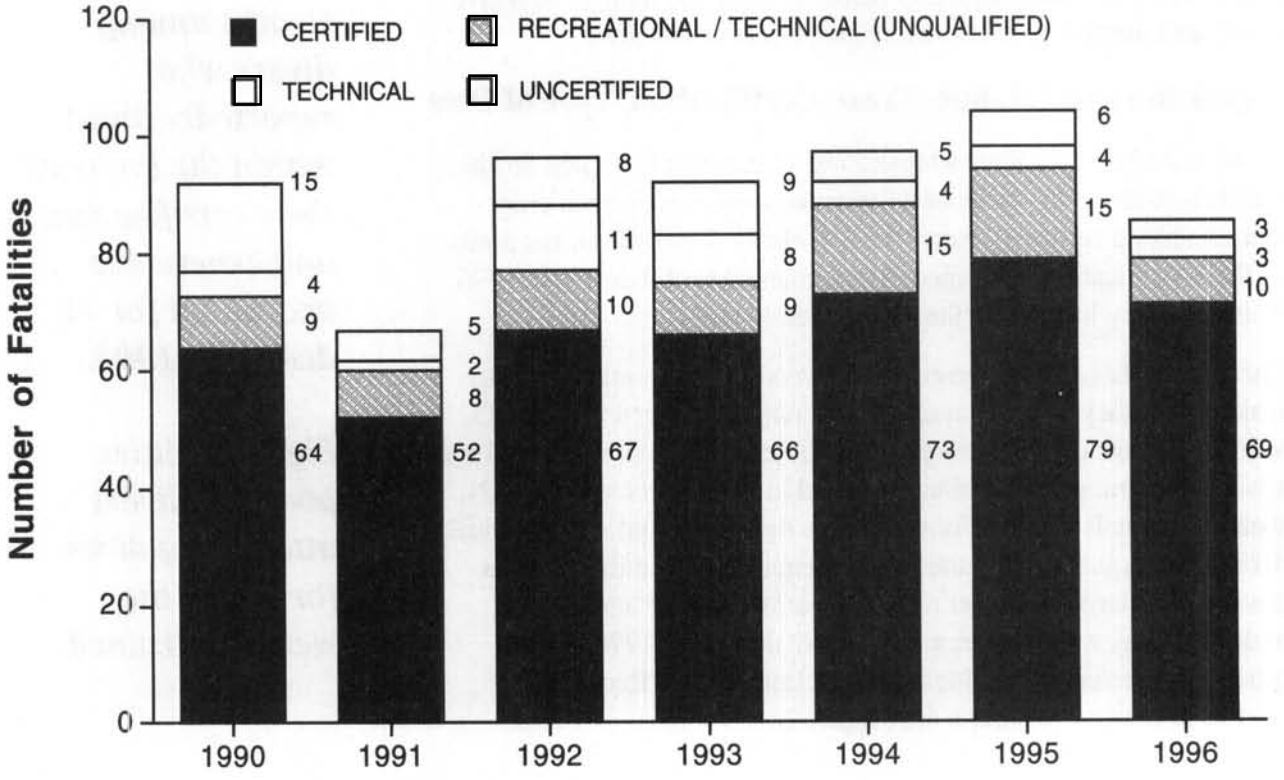
These levels of exposure go beyond established recreational guidelines.

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 1996, technical divers accounted for three fatalities.

In 1996, three dive fatalities involved uncertified divers. These individuals did not participate in an instructional dive course nor were they under the supervision of a dive instructor.

Student fatalities accounted for 13 deaths in 1996. Students represent those individuals under instruction at the time of their accident but are represented in Graph 6.2 (below) in the "Certified" divers column. Four of these students were under instruction for their initial open-water certification. Seven more were seeking advanced open-water certifications. The remaining two were taking a scuba familiarization resort course.

Graph 6.2 *Breakdown of Scuba Fatalities*



Preliminary Report on 1997 Recreational Fatalities

As of November 1, 1997, a total of 66 fatalities have been reported to DAN for 1997. Of these 66 cases, 53 were verified as certified recreational divers, four were students participating in initial training (i.e., an open-water certification or scuba familiarization course), three were considered recreational/technical (unqualified divers, based on reports received at DAN), one was a technical diver, and one was conducting a personal task. There were also four known uncertified divers. Of the 66 fatalities reported thus far in 1997, eight (12.1 percent) have involved women. These are preliminary numbers, and there are likely to be more by the end of 1997.

Over half of the fatalities (71.2 percent) reported so far occurred between May and September: May (4), June (6), July (12), August (13) and September (12). The number of fatalities in August (13) of 1997 is higher than August 1996 (six). The summer months (May-September) usually range from four to 14 deaths per month.

Florida again has the highest number of reported deaths thus far in 1997. Sixteen have been reported as of this writing, which is one more than the 15 deaths confirmed at this time in 1996. California claimed the second highest number of fatalities with eight deaths. Eleven California deaths were reported for all of 1996. New Jersey has had four deaths in 1997, while only one New Jersey death occurred in 1996. North Carolina, Texas, Washington and U.S. Territories each have had three reported deaths. Hawaii, which was the third highest reporting state in diving deaths in 1996 (9), has two diving-related deaths so far in 1997. Nine diving-related deaths have occurred outside of the United States.

Over half of the fatalities (71.2 percent) reported thus far for the 1997 reporting year occurred between May and September.

Methods of Fatality Data Collection

About 32 percent of fatality contacts for 1996 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 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., Luce and Burrelle) and computer electronic mail services (i.e., CompuServe). In 1996, about 32 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 the Internet. Medical examiners, coroners, investigative agencies, hyperbaric chamber personnel and dive agencies may also contact the DAN medical research staff regarding a diving fatality.

Table 7.1 ***Initial Contacts***

	Inside United States	Outside United States	Total	Percent
Subscription Services	31	8	39	45.9
DAN Network	19	8	27	31.8
Investigative*	7	0	7	8.2
Lifeguard/Chamber	5	0	5	5.9
Medical Examiner/Coroner	3	0	3	3.5
E-mail	1	1	2	2.3
Family/Friend	0	1	1	1.2
Newspaper Direct	1	0	1	1.2
Total	**67**	**18**	**85**	**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 the fatality investigations are unfamiliar with scuba diving. DAN offers investigators and medical examiners protocols for investigation and autopsy. In this manner, DAN assists investigation agencies but is not an investigative agency itself.

Table 7.2 *Primary Sources of Information*

Primary Source	Total	Percent
Autopsy and Investigative Report	39	45.9
Autopsy Only	13	15.3
Investigative Report Only	7	8.1
Autopsy and Family/Friend	7	8.1
Family/Friend Only	5	5.9
Newspaper	5	5.9
Investigative Report and Family/Friend	2	2.4
Witness Only	2	2.4
Other	2	2.4
Local Contact Only	1	1.2
Autopsy, Investigative Report and Family/Friend	1	1.2
Autopsy and Witness	1	1.2
TOTAL	**85**	**100.0**

Collecting Information After Initial Contact

Table 7.2 (above) shows the primary sources of information used in the analysis of scuba fatalities. As previously mentioned, DAN usually receives a newspaper clipping, electronic message or a telephone call and uses this as the starting point for the collection of more information.

Once DAN has verified a reported fatality through local authorities, information-gathering begins. 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 1996, in 46 percent of the cases, DAN received an autopsy or coroner's report and an investigative report.

After initial contact, DAN obtains information on fatalities from autopsy or coroner reports and investigative agency reports

If possible, DAN receives statements from persons involved with or witnesses to the dive event. This may include dive buddies, other divers or rescue dive 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.

Diving fatalities fall under the jurisdiction of the local medical examiner, and the decedent is frequently subjected to a forensic autopsy.

Diving fatalities fall under the jurisdiction of the local medical examiner, and the decedent is frequently subjected to a forensic autopsy. In 1996, out of 85 fatalities, a body was recovered in 81 incidents, and autopsies were performed on 71 of these cases; nine decedents did not have an autopsy performed, and one case 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 may decide that one is unnecessary. An autopsy report was available to DAN in 60 out of the 71 cases — which represents 85 percent of all autopsied cases.

In 1996, out of 85 fatalities, a body was recovered in 77 incidents, and autopsies were performed on 67 of these cases.

In general, DAN is receiving more autopsy and investigative reports for analysis because of increased efforts by the DAN medical staff to collect 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 listed on Page 62.

Locations of Scuba Fatalities

Tables 7.3 and 7.4 (Pages 69 and 70) show the location of scuba fatalities included in this report by state within the United States or by foreign locations. No conclusion can be drawn concerning the relative safety or risk of any of the dive locations listed since the total number of dives in each locale is not known. Typically, deaths occur at a variety of dive sites and under various conditions. The number of deaths in Florida and California represent approximately 43 percent of all deaths in the United States, but these deaths occurred at many different dive sites throughout the state.

Table 7.3 *Location of Diving Fatalities by State*

	Certified	Uncertified	Unknown	Total	Percent
Florida	16	1	1	18	21.2
California	10	1	0	11	12.9
Hawaii	7	0	2	9	10.6
Washington	4	0	0	4	4.7
North Carolina	2	0	1	3	3.5
Maine	2	0	0	2	2.3
Massachusetts	2	0	0	2	2.3
New York	2	0	0	2	2.3
Rhode Island	2	0	0	2	2.3
Virginia	2	0	0	2	2.3
Wisconsin	2	0	0	2	2.3
Alaska	1	0	0	1	1.2
Georgia	1	0	0	1	1.2
Kentucky	0	1	0	1	1.2
Louisiana	1	0	0	1	1.2
Michigan	1	0	0	1	1.2
Nevada	1	0	0	1	1.2
New Jersey	1	0	0	1	1.2
Oklahoma	1	0	0	1	1.2
Ohio	1	0	0	1	1.2
Texas	1	0	0	1	1.2
Total	**60**	**3**	**4**	**67**	**78.8**

Florida and California have always led in the number of reported scuba fatalities. This is due in part to large state populations and a large, popular coastline for residents and tourists. Combined with Washington in 1995, they represented 44.2 percent of U.S. fatalities. In 1996, Florida, California and Hawaii accounted for 44.7 percent of all reported U.S. fatalities.

Another large U.S. coastline popular for scuba is between Maine and New Jersey. The nine fatalities here represent 10.4 percent of U.S. fatalities. This same area also accounted for 10.5 percent of the fatalities reported in 1995.

Due to large state populations and large, popular coastlines, Florida and California lead in the number of reported scuba fatalities each year.

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

Country	Certified	Uncertified	Unknown	Total	Percent
Mexico	6	0	0	6	7.0
Cayman Islands	3	0	0	3	3.4
Bahamas	2	0	0	2	2.4
Belize	2	0	0	2	2.4
Barbados	1	0	0	1	1.2
Philippines	1	0	0	1	1.2
Puerto Rico	1	0	0	1	1.2
Saudi Arabia	1	0	0	1	1.2
U.S. Virgin Islands	1	0	0	1	1.2
Total	**18**	**0**	**0**	**18**	**21.2**

The number of U.S. citizens who died while scuba diving abroad represented 21.2 percent of all fatalities recorded in 1996.

Based on reports to DAN, the number of U.S. citizens who died while scuba diving abroad represented 21.2 percent of all fatalities that met the inclusion criteria in 1996. The percentage is up from 17.4 percent of the 1995 fatalities, but the number of deaths for each year is the same (18).

DAN makes every effort to track and record fatalities of U.S. residents, no matter where in the world they occurred. If a geographical area is not listed in Table 7.4, DAN recorded no fatalities in that area.

To report an injury, a fatality or a near-miss in diving, call DAN's Medical Department at +1-919-684-2948

Divers Alert Network
The Peter B. Bennett Center
6 West Colony Place
Durham, NC 27705

Fatality Dive Profile

Primary Dive Activities

Table 8.1 (below) shows the primary dive activity of the 85 divers who died in 1996. The most common category of diving deaths was "pleasure/sightseeing." In the last three DAN reports, the second most common dive activity associated with reported scuba fatalities was diving while under instruction. Of the 13 cases reported, four were under initial instruction, two were in a scuba familiarization course and seven were in an advanced certification course. Those in an initial certification or scuba familiarization course are considered in the "uncertified" column. Three divers had no record of any formal dive training, and the level of training, if any, in six 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 stretch the limits of their diving skills and engage in specialty type dives (e.g., caves, wrecks, deep diving) without proper training or experience. Each year a small number of people die while attempting to use scuba diving equipment without any formal training and often without proper equipment.

Sightseeing and Instruction

Most people scuba dive for sightseeing or pleasure. Nearly half of all fatalities (43.5 percent) occur to divers participating in the sport during these two activities, according to DAN statistics.

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Table 8.1 ***Primary Dive Activity***

Dive Activity	Certified	Uncertified	Unknown	Total	Percent
Pleasure/Sightseeing	34	1	2	37	43.5
Under Instruction	7	6	0	13	15.3
Spearfishing/Hunting	7	2	0	9	10.6
Wreck*	8	0	0	8	9.4
Cave*	6	0	0	6	7.0
Unknown	1	0	3	4	4.7
Work	2	0	1	3	3.5
Deep (> 130 feet)*	2	0	0	2	2.4
Night	2	0	0	2	2.4
Providing Instruction	1	0	0	1	1.2
TOTALS	**70**	**9**	**6**	**85**	**100.0**

**Technical dives*

Working Dives, Spearfishing & Underwater Photography

As noted in previous years, a "working dive" for the purpose of the DAN database is a dive where scuba equipment is used to accomplish a specific dive-related or personal task. Military, commercial and scientific diving fatalities are not included in the DAN database and, truthfully, those numbers are extremely small. The working dives in DAN 1996 fatality database include individuals who were attempting to perform boat repairs, salvage lost personal gear, free a fouled anchor line or recover a sunken snowmobile. As in previous years, 10 percent of the recreational diving fatalities that occurred in 1996 involved divers who were either spearfishing or collecting lobster and other shellfish. Divers should take extra caution when performing tasks that may divert their attention from exercising fundamentally safe diving techniques.

There were 13 deaths in 1996 that occurred while the diver was performing a technical dive.

Technical Dives

There is no universally accepted definition of what constitutes a "technical dive" or, for that matter, a "technical diver." DAN has defined "technical dive" as one in which one of the following conditions existed (see Page 64).

- Diving deeper than 130 feet / 40 meters;
- Using a breathing mixture other than compressed air;
- Decompression or overhead diving (diving in shipwrecks or caves);
- Special training and equipment were used.

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. For the purpose of this report, DAN has placed extraordinarily deep dives, wreck penetration dives, and cave dives into the category of technical dives.

Thirteen deaths occurred in 1996 while the diver was performing one of these technical dives. Three of these 13 fatalities were certified as "technical" divers and were using specialized equipment. The majority of these fatalities involved individuals who were ill-prepared (lacking specialized training, certification or equipment) for the type of diving they were performing. Cave diving deaths decreased from nine in 1995 to five in 1996. One double fatality incident occurred in 1996, while two were reported in 1995. Only one of the cave divers in the 1996 database 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. A specialty 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 (below) shows the type of dive platforms used by divers involved in a fatal diving incident. In most years for which DAN has data, a shore entry was utilized in less than half of the fatal dives. Charter- or private-boat diving made up a total of 57.6 percent of all scuba fatalities in 1996, which was virtually unchanged from 58.6 percent in 1995. There were no fatalities involving a diver using scuba gear in a swimming pool in 1996.

The greatest number of 1996 fatalities occurred during dives that had two divers in the dive group.

Table 8.2 ***Percentage of Dive Platform Use***

Entry	1996	1995	1994	1993	1992	1991	1990
Shore	40.0	39.4	27.8	44.6	39.2	49.3	47.8
Charter Boat	38.8	35.5	30.9	32.6	26.8	28.4	30.4
Private Boat	18.8	23.1	39.3	20.6	29.9	20.9	20.7
Pool	0.0	1.0	1.0	1.1	1.0	1.5	0.0
Unknown	2.4	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**	**100.0**

Number of Divers in Groups When Fatal Injuries Occurred

Table 8.3 (Page 74) shows the number of divers reported to be in a dive group at the time of the fatality. As in previous years, the greatest number of fatalities occurred during dives that had two divers in the dive group. The percentage of fatalities occurring in dive groups containing either three divers or greater than 10 divers decreased from 1995 to 1996.

The percentage of fatalities occurring in dive groups containing either three divers or greater than 10 divers decreased from 1995 to 1996.

While it is encouraging that the number of unaccompanied divers involved in a fatal diving mishap dropped last year, a significant percentage (8.2 percent) of mishaps in 1996 involved divers entering the water without a buddy.

The information submitted in cases indicate that there were also 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 violation of accepted safe diving procedures.

In the DAN database, separation from the buddy is reported in nearly two-thirds of the fatalities that occur each year. While diving with a buddy may range from close contact throughout the dive to being in the same general area as your buddy, having another diver available to render assistance may mean the difference

Table 8.3 *1996 - Number of Divers in a Group*

Number in Dive Party	1996 Percent	1995 Percent	1994 Percent	1993 Percent
1	8.2	15.4	6.2	5.4
2	21.2	20.2	22.6	25.0
3	12.9	17.3	16.5	10.9
4	11.8	12.5	11.3	9.8
5	9.5	2.9	6.2	8.7
6	5.9	4.8	6.2	4.3
7	5.9	1.9	2.1	2.2
8	3.5	1.9	2.1	3.3
9	0.0	1.0	2.1	1.1
≥10	12.9	18.3	15.4	15.2
Unknown	8.2	3.8	9.3	14.1
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**

Buddy separation eliminates the availability of immediate assistance.

between life and death. Buddy separation eliminates the availability of immediate assistance and may significantly increase 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 (below and Page 75) 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.

Predive and many post-dive events are frequently associated with pre-existing health problems such as cardiovascular disease.

Table 8.4 *When Problem Occurred*

	1996 Percent	1995 Percent	1994 Percent	1993 Percent
Late Dive	30.6	20.2	29.9	31.5
Post Dive	20.0	16.3	20.6	16.3
Unobserved	16.5	32.7	23.8	9.8
Mid Dive	15.3	8.7	5.2	15.3
Early Dive	12.9	11.5	11.3	15.2
Unknown	3.5	2.9	4.1	4.3
Surface - Predive	1.2	5.8	4.1	6.5
Upon Entry	0.0	1.9	1.0	1.1
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**
	n=85	*n=104*	*n=97*	*n=92*

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 (i.e., running out of air). Eleven fatalities (12.9 percent) were directly attributed to insufficient air. While two of these insufficient air fatalities were complicated by the diver having been entrapped in a cave (2), many of the fatalities occurred to divers who ran out of air in the open water (9). "Unobserved" relates to cases where the incident was not witnessed by anyone, while "unknown" refers to cases where there was no available information.

Eleven fatalities (12.9 percent) were directly attributed to the diver running out of air.

Table 8.5 ***Where Problem Occurred***

	1996 Percent	1995 Percent	1994 Percent	1993 Percent
Surface Post Dive	28.2	21.2	25.8	16.3
During Ascent	24.7	14.4	16.5	22.8
At Depth	21.2	15.4	29.8	32.6
Unobserved	15.3	32.7	16.5	12.0
Descent	5.9	7.6	4.2	5.4
Unknown	3.5	2.9	3.1	4.4
Surface-Predive	1.2	5.8	4.1	6.5
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**
	n=85	*n=104*	*n=97*	*n=92*

Summary

■ In order to calculate the true incidence of diving injuries and fatalities it is necessary to know how many uneventful dives occur each year. For 1996, as in previous years, this figure can only be estimated.

■ DAN has initiated Project Dive Exploration in order to more accurately determine the number of dives performed each year. The project will begin officially collecting data in January 1998. Additionally, there are cases in our database each year where little information is known about the incident or the body is not recovered. The significant number of fatalities which involved divers who were in the water unaccompanied must leave us to only speculate on what may have gone wrong during those dives. The contributing factors and circumstances surrounding these fatalities are not known and cannot appear in the DAN database.

Dive Fatalities Among Certified Divers

The greatest number of diving fatalities in 1996 occurred in the 30- to 39-year-old age group, similar to what DAN reported in 1995.

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

Age and Gender in Diver Fatalities

The ages and the gender for the 82 certified divers are shown in Table 9.1 (below). The female fatalities represent 18.3 percent of all of the 1996 scuba deaths compared to 15.3 percent in 1995. This information will only truly become more meaningful when the number of dives made by women compared to men each year are known. The age range for female divers was 24 to 64 years of age; males ranged from 21 to 71 years of age. The age distribution is similar to that observed in the 1995 database except that there were no fatalities involving individuals who were younger than 20 years old in 1996. Similar to what DAN reported in 1995, the greatest number of diving fatalities in 1996 occurred in the 30- to 39-year-old age group.

Table 9.1 *Age and Gender Comparison of 1996 Fatalities*

Age	Male	Female	Total	Percent
10 - 19	0	0	0	0.0
20 - 29	8	3	11	13.4
30 - 39	27	1	28	34.2
40 - 49	18	6	24	29.3
50 - 59	12	4	16	19.5
60 - 69	1	1	2	2.4
70 - 79	1	0	1	1.2
TOTAL	**67**	**15**	**82**	**100.0**

Certification Levels Among Fatalities

Table 9.2 shows the level of certification among the 1996 scuba fatalities. The distribution is similar to that observed over the last several years. One notable observation is the increase in the number of initial open-water certification students involved in a fatal diving mishap. Sixty-six percent of victims of a fatal diving mishaps in 1996 involved a diver with no more than initial open-water certification training. While this may suggest that increased training could prevent many diving injuries, it is not known how many dives are completed by persons with open-water certification compared to the number completed by divers with advanced training. There was a slight decrease in fatalities involving divers with advanced open-water certification in 1996 compared to 1995.

66 percent of fatal diving mishaps in 1996 involved a diver with no more than initial open-water certification training.

Table 9.2 *Certification Level of 1996 Fatalities*

Certification Level	Total	Percent
Open Water/Basic	48	58.5
Advanced	9	11.0
Unknown	7	8.5
Student*	6	7.4
Instructor	6	7.4
Rescue	2	2.4
Dive Master	2	2.4
Cave Diver	1	1.2
Nitrox	1	1.2
TOTAL	**82**	**100.0**

* *Under initial training or in scuba familiarization course.*

Fatalities Grouped by Experience Levels

Table 9.3 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 very inexact. Another factor that is considered to figure highly in diving fatalities is the diver's familiarity with the activity or environment.

Table 9.3 *Diving Experience During Diving Activity*

	Overall Experience		Within Activity or Environment	
	Total	Percent	Total	Percent
Student	6	7.3	6	7.3
Novice (≤ 5 dives)	9	11.0	7	8.5
Inexperienced (6 - 20 dives)	18	22.0	25	30.5
Intermediate (21 - 40 dives)	12	14.6	7	8.5
Advanced (41 - 60 dives)	3	3.7	6	7.3
Experienced (≥ 61 dives)	27	32.9	19	23.2
No experience	0	0.0	5	6.2
Unknown	7	8.5	7	8.5
TOTAL	**82**	**100.0***	**82**	**100.0***

** Percent of certified divers / students*

In 1996, 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, provides enlightening information about factors which may lead to a fatal dive profile. "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 involved in (e.g., cave diving, deep diving, wreck diving, etc.) or environment (kelp bed, freshwater, etc.) at time of death. This information is obtained from family, witnesses, and investigative reports.

As in previous years, the most fatalities in any single experience group occurred among those divers with 61 or more lifetime 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. Additionally, more experienced divers may engage in more challenging dive activities. DAN can only speculate on whether or not 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 decrease in deaths in any experience group occurred in the advanced, or 41-60 dives group. Fatalities have dropped overall, as well as those involving students in initial training, which has decreased from six in 1995 to four in 1996.

The greatest increase in deaths among divers under the fatalities category "within activity or environment" occurred in the novice group which increased from four fatalities in 1995 to seven in 1996. This increase was balanced by a slight decrease in fatalities occurring in each of the other experience level groups.
The inexperienced group consistently 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 novice group.

Appendix A

1996 Fatality Case Reports with Autopsy Findings

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

Introduction / Overview

During the reporting year of 1996, Divers Alert Network collected information on 85 scuba-diving related fatalities. In four cases, a body was not recovered; an autopsy was not performed in nine cases that were reported to DAN; and one case did not have enough information to determine if an autopsy was performed. In an additional 11 cases, an autopsy was performed, but little or no information regarding the findings of the postmortem examination was made available.

As stated in previous years, the purpose of this section is to use the case summaries to describe factors which may have contributed to fatal diving mishaps. This 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. Diver education is a major function of Divers Alert Network, and our hope is to prevent future mishaps by reviewing the circumstances associated with fatal outcomes.

In this section, the causes of death and the factors contributing to the death are listed using 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]. DAN has adapted a few of the environmental (the numbers preceded by an E) codes to make them more specific for describing some of the contributing causes of death in diving fatalities. The most frequently used codes 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. DAN is indebted to many sources for gathering and contributing information on diving fatalities. Their cooperation is essential in our effort to put together this section. In most cases, 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 about the victim's physical and emotional state on the day of the mishap;
- The dive profile, including the depth and bottom 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 performed and the decedent's response, if any, to therapy;
- 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 used to maximize the amount of information gained during the postmortem examination of a suspected diving fatality victim. The autopsy protocol included as Appendix B is a modification of a protocol that originally appeared in the 1992 *Report on Diving Accidents and Fatalities*[2]. It is recommended that this protocol be used as a guideline when performing postmortem examinations on diving fatality victims. Erroneous conclusions are occasionally drawn from obtaining air through a simple thoracic puncture or seeing bubbles distributed within the cerebral and coronary vessels

and the vena cava. Intravascular gas is not conclusive evidence supporting a diagnosis of air embolism or decompression sickness in someone who was breathing compressed air prior to death. All available pieces of information, especially those items listed above, should be taken into consideration before arriving at a conclusion regarding the cause of death in a diving fatality.

Diving fatalities are nearly always initially categorized as non-natural deaths, and in most states the medical examiner system assumes jurisdiction over the case. Autopsies are performed at the discretion of the medical examiner. In most cases, a postmortem examination is ordered. It is recommended that a complete autopsy be performed in all diving fatalities and accidental drownings. The final event in most diving fatalities is drowning, but the circumstances and events that resulted in the drowning are far more important pieces of information. Furthermore, drowning is basically a diagnosis of exclusion. It may be argued that without a complete postmortem examination, many possible causes of death have not been excluded[3].

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. Cases are identified by a code number and patient confidentiality is strictly maintained. Eleven cases included an autopsy, but the findings were not made available to DAN. Nine cases did not include a postmortem examination, and one did not have enough information to make a determination. Four cases involved fatalities where a body was never recovered. These other categories of cases are presented after the section on autopsied cases and the same classification scheme is used.

Autopsied Cases

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

Contributing Factors: Cardiovascular Disease and Inexperience

At the risk of being repetitive, special mention must again be made regarding the high incidence of cardiovascular disease among the 1996 fatalities. At the 1997 annual meeting of the Undersea and Hyperbaric Medical Society, DAN presented data on the occurrence of cardiovascular disease as the cause of death or contributing to the cause of death in diving fatalities. During the period 1990 to 1995, cardiovascular disease contributed to 12 percent of all diving fatalities. It was a factor in 26 percent of all fatalities that involved divers over 35 years of age and was second only to drowning as the leading cause of death in this age group[4]. Cardiovascular disease is the number one cause of death for both men and women in the United States and most other developed countries[5]. The diver with atherosclerotic coronary artery disease is at an increased risk for a myocardial infarction or sudden cardiac death.

Of the 60 cases for which we have autopsy information in 1996, 16 included cardiovascular disease as the primary cause of death or as a contributing factor to the primary cause of death. In several other cases, incidental coronary atherosclerosis was noted during the postmortem examination. Most recreational diving is not considered strenuous exercise, but there is always a component of physical activity and occasional exertion involved. A greater level of physical activity may be required under certain circumstances such as swimming against a strong current or assisting another diver. A diver may need to call on some physical reserve in order to extricate him- or herself from a difficult situation. Additionally, most diving takes place in areas that are remote from a tertiary medical care facility, and the mere fact that the diver is in the water makes surviving a cardiac event much less likely.

Diving should be considered a potentially strenuous activity and one that requires an adequate level of physical and cardiovascular fitness. Prior to entering initial diving training, individuals would be wise to have their health and fitness status reviewed by a physician. Older individuals who desire either to continue diving or wish to participate in an initial diving certification class should have a thorough physical examination with appropriate assessment of their cardiovascular fitness. An electrocardiogram and exercise treadmill test are strongly encouraged.

Inexperienced divers were over-represented among the fatalities reviewed by DAN from 1991 to 1994[6], and that trend continued in 1996. Inexperienced divers include divers who are in their initial open-water certification course and those divers who have performed 20 or fewer open-water dives after completing their training. As in previous years, between 30 and 40 percent of the fatalities involved inexperienced divers in 1996. Hopefully, Project Dive Exploration will provide some insight with regard to how many dives are being performed by divers of the different levels of experience, allowing more meaningful interpretation of this data. Despite the inability to apply sound statistical methods to the data, it is safe to say that inexperienced divers are over-represented in the dive fatality database.

Many experienced divers continue to get into difficulty when they stretch the limits of their training and attempt specialty dives such as cave exploration and wreck penetration without formal training. These types of dives require specialized equipment, sound dive planning, and redundant backup emergency systems. Formal training is essential prior to participating in these more specialized types of dives. 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 DAN fatality case studies is to help avoid future injuries. We can educate ourselves and our fellow divers by sharing the lessons learned from the unfortunate experiences of others. If we are successful in our efforts, those of us at DAN would like to be able to have nothing to report in the fatality section of future reports. In order to accomplish this goal, DAN advocates the following:

- Physical fitness and proper nutrition;
- Appropriate training and education;
- Proper and well-maintained equipment;
- Safe and conservative diving habits.

Promoting these precepts to divers of all levels, from novice to instructor, can help reach DAN's goal of safer diving for everyone.

The 1996 database of scuba diving fatalities can be found on the following pages.

LEGEND FOR FATALITY SUMMARIES

R: Recreational diver
R/T: Recreational/Technical diver (conducting a technical dive not qualified for)
T: Technical diver
U: Uncertified diver (without a scuba certification from a national agency)

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;
- A pressure change being required to produce the disease; and
- Similar treatment.

The 1996 autopsy series in the DAN database includes one fatality due to decompression sickness. DCS is an infrequent cause of death in diving, but it can result in permanent disability and even paralysis. When DCS does result in death, the victim usually succumbs to complications of a prolonged hospitalization and the multiple medical problems that accompany the process, e.g., respiratory distress syndrome, disseminated intravascular coagulation or pulmonary embolism.

There were seven cases of fatality due to air embolism and an additional three cases of drowning secondary to air embolism in 1996. In many cases, these fatalities involved inexperienced divers — running out of air and panic were frequently part of the scenario. Inexperience is also a contributing factor in cases of divers who survive an arterial gas embolism[7].

During initial dive certification training, buoyancy control and slow ascent rates cannot be overemphasized. Divers must gain 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.

Decompression Sickness

DAN RECORD NO: 2196 **AGE:** 32 **SEX:** M **DIVER CAT:** R/T

Cause of Death	**ICD-9-CM**
Immediate: Adult respiratory distress syndrome	518.5
Due to: Decompression sickness	993.3
Due to: Rapid ascent	E902.2
Due to: Insufficient air	E913.2
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Panic	308.0
Nitrogen narcosis	293.0
Tobacco abuse	305.1

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

This 32-year-old, moderately experienced, certified diver made a dive to 276 fsw on air to explore a wreck. His two dive buddies stated that the decedent's regulator was free-flowing, which caused him to run out of air before any decompression obligation could be met. The decedent went directly to the surface after a 14 minute bottom time, and he immediately radioed for help before becoming paralyzed and unconscious. The diver was treated with HBO for several days before developing pulmonary complications and dying three weeks later. The autopsy report lists the cause of death as nitrogen narcosis, which most likely was a factor but was not the proximate cause of death. This death was most likely due to severe decompression sickness or possibly an air embolism.

Air Embolism

DAN RECORD NO: 696 **AGE:** 34 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Air embolism	958
Due to: Rapid ascent	E902.2
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Subcutaneous emphysema	958.7
Barotrauma, otic	993
Significant Incidental Findings:	
Coronary artery disease, mild	414.9

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

This 34-year-old male was a student in an initial open-water certification class making his final check-out dive before certification. The dive was planned to a depth of 50 fsw in a quarry located at an altitude of approximately 1500 feet above sea level. The decedent became separated from the instructor and another student. When the instructor and student ascended to look for the decedent, they saw him blow up (rapidly ascend) to the surface and come up out of the water. The decedent was unconscious and could not be resuscitated. An examination of the dive gear showed that the decedent had been down to 100 fsw. The autopsy revealed 130 cc of intracardiac air and evidence of pulmonary barotrauma.

DAN RECORD NO: 1396 **AGE:** 38 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Air embolism	958.0
Due to: Rapid ascent	E902.2
Due to: Panic	308.0
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Obesity	278.0

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

This 38-year-old male diver received his initial open-water certification five months earlier. He and two equally novice dive buddies made a shore entry into a rip current and spent only five minutes at 10 fsw before aborting the dive. While under the surface, the decedent became very anxious and surfaced. After the decedent became unconscious on the surface, he was assisted to shore by his dive buddies and a lifeguard. Cardiopulmonary resuscitation was unsuccessful. The autopsy disclosed gas in the cerebral and coronary vessels which supports a diagnosis of air embolism, especially with a short shallow dive profile.

DAN RECORD NO: 2996 **AGE:** 34 **SEX:** M **DIVER CAT:** R

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

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

This 34-year-old male had only been a certified diver for less than one month when he made a 60 fsw dive for 25 minutes. The decedent wore 30 pounds of weight on his belt and reportedly had some difficulty with the belt itself. His buddy attempted to assist him, but the two divers became separated in a current. The buddy found the decedent unconscious and on the surface. Resuscitation efforts were unsuccessful. The autopsy procedure was not ideal for demonstrating an air embolism, but the dive profile and several findings present at autopsy make this a likely cause of death.

DAN RECORD NO: 4696 **AGE:** 71 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Air embolism	958.0
Due to: Pulmonary barotrauma	993.9
Due to: Scuba diving	E910.1

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

This 71-year-old male made a shore entry dive with a group of other divers to a maximum depth of 70 fsw. Little is known about the decedent's diving experience and health status. The events of the mishap are unknown since the decedent chose to dive without a buddy. The autopsy, which was performed three days after death, revealed gas in the coronary and cerebral vessels. The medical examiner concluded the cause of death to be an air embolism, but without adequate history the observations in an autopsy performed three days after death are of minimal use in evaluating a diving fatality.

DAN RECORD NO: 5696 **AGE:** 42 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Anoxic encephalopathy	348.1
Due to: Air embolism	958.0
Due to: Rapid ascent	E902.2
Due to: Entrapment (ledge, transient)	E918

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

Paralysis	344.1

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

A 42-year-old, inexperienced, infrequent diver made three shore entry dives into a quarry with his buddy. The decedent was paralyzed from the waist down due to a previous injury. During the third dive the decedent became entrapped briefly under a ledge. When he freed himself, the decedent rapidly went directly to the surface. Initially, the diver appeared fine, but his condition rapidly deteriorated to unconsciousness and he was taken to the local hospital. After four days on life support, the diver was pronounced dead and his organs were harvested for donation. The autopsy lists drowning as the cause of death, but the history is more compatible with an air embolism as the primary event.

DAN RECORD NO: 6096 **AGE:** 54 **SEX:** F **DIVER CAT:** R

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

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

Depression	296.2
Antidepressant medications	939.0
Arthritis	716.9
LVH, mild	429.3

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

This 54-year-old, female, certified diver with approximately 60 lifetime dives was using a drysuit with which she was

unfamiliar. During the second dive of the day, the decedent had significant buoyancy problems and inverted her body position in the water. She then made a witnessed rapid ascent to the surface where she struggled and would not accept assistance. The decedent quickly lost consciousness and resuscitation procedures were initiated. She was pronounced dead on arrival at the hyperbaric chamber. The autopsy report was not made available. Evidence corroborating air embolism as the cause of death included subcutaneous emphysema, pneumopericardium and intracardiac/intravascular gas.

DAN RECORD NO: 7596 **AGE:** 45 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Air embolism	958.0
Due to: Rapid ascent	E902.2
Due to: Insufficient air	E913.2
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Left ventricular hypertrophy	429.3
Coronary atherosclerosis	414.0
Obesity	278.0

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

This 45-year-old male diver had recently completed initial open-water training and had made less than five lifetime dives. He was diving with two buddies but became separated from them. During the second dive of the day, the decedent was seen to surface, immediately call for help, and then lose consciousness. Other members of the group began cardiopulmonary resuscitation and the diver was taken to the hyperbaric chamber where he was pronounced dead on arrival. The decedent's tank was empty, but all other dive equipment was functioning adequately. His dive computer showed that he exceeded a 60 feet per minute ascent rate on both dives that day.

Drowning With Air Embolism

DAN RECORD NO: 396 **AGE:** 37 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Air embolism	958.0
Due to: Pulmonary barotrauma	993.9
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Obesity	278.0
Left ventricular hypertrophy	429.3
Alcohol use (73mg/dL)	305.0

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

A 37-year-old, male, certified diver with 25 lifetime dives was spearfishing with a group of divers. After the dive, the decedent surfaced, appeared to be in distress, and then descended back to the bottom. No information is available on the dive profile and any problems the diver may have experienced while in the water. The body was recovered two hours later. The autopsy, which was done appropriately to assess for air embolism, showed intracardiac gas and pulmonary hemorrhages. Without more history, a cardiovascular cause of death cannot be excluded.

DAN RECORD NO: 2596 **AGE:** 23 **SEX:** M **DIVER CAT:** R/T

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Air embolism	958.0
Due to: Rapid ascent	E902.2
Due to: Insufficient air	E913.2
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Nitrogen narcosis (presumed)	293.0

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

A 23-year-old male, who was a certified rescue diver but had little experience in deep and wreck diving, made a

planned decompression dive to 154 fsw with a small group of divers. Almost immediately after touching bottom, the decedent signaled to his buddy that he was having problems with his air source. The two divers decided to ascend but became separated before reaching the surface. The decedent was found nearly an hour later and was pronounced dead at a local hospital. The autopsy revealed intravascular air as well as subcutaneous emphysema.

DAN RECORD NO: 7996 **AGE:** 53 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Air embolism	958.0
Due to: Rapid ascent	E902.2
Due to: Panic	308.0
Due to: Scuba Diving	E910.1

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

Facial resection with deformity	738.1

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

This 53-year-old male had made 10 lifetime dives including his open-water certification dives. He was in a group of five divers and during the second dive of the day was witnessed to panic on the bottom and ascend rapidly to the surface. The decedent was unconscious on the surface and could not be resuscitated. The autopsy showed minimal evidence of pulmonary barotrauma, but the history supports an air embolism as the inciting event. There was considerable fluid in the airways and sinuses. The decedent had prior surgery that resulted in resection of the hard palate, part of the maxilla, and one eye. He wore a special full face mask to compensate for these defects. It is possible that water entered the decedent's mask causing problems because of his surgical defects, which may have resulted in the initial panic episode.

Cardiovascular Disease

The problem of cardiovascular disease in the diving population 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 increasing age as well.

Exertion increases the cardiac output and the need for oxygen by the myocardium (heart muscle). If the vessels supplying blood, and ultimately oxygen, to the heart are narrowed by atherosclerosis, 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 regarding his or her participation in any recreational activity. Additionally, when performed correctly, diving is a buddy activity, and the buddy should be made aware of any significant health problems possessed by the other member of the team.

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, including an evaluation of cardiovascular fitness.

In the following cases, many individuals had silent cardiovascular disease, which initially manifested itself during a dive with catastrophic outcomes. There is a smaller category of cases where the diver had known health problems that may have been disqualifying for diving.

DAN RECORD NO: 196 **AGE:** 64 **SEX:** F **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Cardiac dysrhythmia	427.9
Due to: Coronary atherosclerosis	414.0
Other significant conditions contributing to death but not resulting in the underlying cause:	
Scuba diving	E910.1
Tobacco abuse	305.1
Significant Incidental Findings:	
Arterionephrosclerosis	403.9

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

This 64-year-old woman was an experienced certified diver who was spearfishing with several divers in an area where the depth was 50 to 60 fsw. Near the end of the dive, the decedent became separated from her buddy when a fishing boat trolled through the dive site and the visibility was reduced. The other divers noticed she was missing and immediately began a search for the decedent. She was found unconscious and on the bottom. Resuscitation efforts were unsuccessful and the diver was pronounced dead at a local hospital. The autopsy showed a critical stenosis in the proximal right coronary artery. The decedent's tank was also reported to be nearly empty, and it is uncertain what impact, if any, the fishing boat had on this diving fatality.

DAN RECORD NO: 896 **AGE:** 45 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Cardiac dysrhythmia	427.9
Due to: Coronary atherosclerosis, severe	414
Other significant conditions contributing to death but not resulting in the underlying cause:	
Scuba diving	E910.1
Tobacco abuse	305.1

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

A 45-year-old male was a certified diver with approximately 40 lifetime dives. He made a dive to 74 fsw with a group of divers but became separated from his buddy 15 minutes into the dive. The decedent was seen to surface and gave an OK signal before becoming unconscious and going beneath the surface. An evaluation of the decedent's equipment showed that the tank contained only 200 psi of air and his computer indicated that he had exceeded the prescribed ascent rate. The autopsy, which was performed by a pathologist with a knowledge of diving physiology, failed to reveal evidence of air embolism or pulmonary barotrauma. The cause of death was determined to be a cardiac dysrhythmia.

DAN RECORD NO: 1496 **AGE:** 43 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Cardiac dysrhythmia	427.9
Due to: Coronary atherosclerosis, severe	414.0
Other significant conditions contributing to death but not resulting in the underlying cause:	
Scuba diving	E910.1
Left ventricular hypertrophy	429.3

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

A 43-year-old male student in an advanced open-water class received his initial diving certification six months earlier and had made less than 20 lifetime dives. He had made three uneventful dives the previous day and made a shore entry dive to a planned depth of 80 feet with his buddy as the first dive during the second day of the course. After experiencing difficulty in descending, the diver added four pounds of weight and went down to 50 feet. At this point, the diver became visibly distressed and his buddy came to his aid. The buddy attempted to drag the decedent to the surface but lost his grip and called for help. The decedent was pulled up by other divers in the area, but resuscitation efforts were unsuccessful. The dive buddy was treated successfully for an air embolism.

DAN RECORD NO: 1696 **AGE:** 41 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Cardiac tamponade	423.9
Due to: Acute myocardial infarction with rupture	410.9
Due to: Coronary atherosclerosis	414.0
Other significant conditions contributing to death but not resulting in the underlying cause:	
Hypertension	401.9
Obesity	278.0
Ethanol use, episodic	303.2
Elevated serum lipids	272.4
Pulmonary emphysema	492.8
Tobacco abuse	305.1
Significant incidental diagnoses	
Fatty liver	571.8

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

This diver was a 41-year-old male instructor with extensive diving experience who also had numerous risk factors for heart disease. The decedent had been complaining of chest pain for at least two days when he decided to lead a group of divers on a wreck dive in 150 fsw. Just a few minutes into the dive, the decedent was noted to be on the bottom, unconscious with his regulator out of his mouth. He could not be resuscitated. The autopsy disclosed the cause of death (200 cc of blood in the pericardial sac), as well as many other disease processes.

DAN RECORD NO: 2296 **AGE:** 51 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Cardiac dysrhythmia	427.9
Due to: Coronary atherosclerosis, severe	414.0
Other significant conditions contributing to death but not resulting in the underlying cause:	
Hypertension	401.9
Left ventricular hypertrophy	429.3
Toxicology positive for antidepressants	E939.0

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

This 51-year-old male was a student making his fourth open-water dive for initial certification. At the end of the dive, the decedent ascended up the anchor line and appeared disoriented on the surface. He became unconscious and was quickly brought to the boat where resuscitation efforts were unsuccessful. During the rescue, an attempt was made to remove the decedent's weight belt, but it was caught under his equipment. The autopsy revealed severe cardiac disease and no evidence of pulmonary barotrauma or air embolism.

DAN RECORD NO: 2696 **AGE:** 27 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Cardiac dysrhythmia	427.9
Due to: Hypertrophic cardiomyopathy	425.4
Other significant conditions contributing to death but not resulting in the underlying cause:	
Obesity	278.0
Hypertension	401.9
Scuba diving	E910.1

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

This 27-year-old male had 15 lifetime dives and hadn't made a dive in nearly 2 years. He and three friends made two shore entry dives to a maximum depth of 30 feet for an average of 30 minutes. During the first dive, the decedent had buoyancy problems and compensated for this by placing rocks in his BC jacket pockets. The decedent reportedly complained of heartburn and fatigue between dives. During the second dive, the divers' flag became tangled in a line and the dive was aborted early. The decedent, who had become separated from the other divers, called for help on the surface and then became unconscious. Resuscitation efforts were unsuccessful. An evaluation of the equipment revealed that the regulator was hooked up improperly, and the low-pressure inflator to the BC was not attached. An air embolism is also a possibility in this case, but the autopsy findings were more convincing for a natural cause of death.

DAN RECORD NO: 3096 **AGE:** 53 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Myocardial infarction (acute & remote)	410.9
Due to: Coronary atherosclerosis, severe	414.0
Other significant conditions contributing to death but not resulting in the underlying cause:	
Left ventricular hypertrophy	429.3
Diabetes mellitus	250.0
Cerebrovascular disease	437.0
Tobacco abuse	305.1
Hypertension	401.9
Obesity	278.0
Renal Arteriolosclerosis	403.9
Hypercholesterolemia	272.4

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

This 53-year-old male certified diver had less than 20 lifetime dives. He had numerous medical problems, for which he required several prescription medications. At the end of a dive to 55 fsw for 20 minutes, the decedent had an uneventful ascent, but complained of shortness of breath on the surface. He rapidly lost consciousness and sank below the surface. Another diver pulled the victim up from approximately 15 fsw and resuscitation procedures were initiated. The diver was pronounced dead upon arrival at a local hospital. The autopsy disclosed severe coronary atherosclerosis and evidence of acute and remote myocardial infarcts.

DAN RECORD NO: 3296 **AGE:** 48 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Cardiac dysrhythmia	427.9
Due to: Coronary atherosclerosis	414
Other significant conditions contributing to death but not resulting in the underlying cause:	
Scuba diving	E910.1
Sarcoidosis	135.0
Fatty liver	571.8

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

This 48-year-old male had been certified for one year and had eight total lifetime dives. He made an uneventful dive to 60 fsw for 15 minutes but became unconscious on the surface after the dive. Resuscitation efforts were unsuccessful. The autopsy showed 50 percent occlusion of the left anterior descending artery. The role that sarcoidosis may have played cannot be determined with any certainty.

DAN RECORD NO: 3796 **AGE:** 54 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Cardiac dysrhythmia	427.9
Due to: Coronary atherosclerosis	414.0
Other significant conditions contributing to death but not resulting in the underlying cause:	
Scuba diving	E910.1
Acute alcohol intoxication (blood level 0.16 gm%)	305.0
Pulmonary emphysema	492.8
Pleural adhesions	511.0
Left ventricular hypertrophy	429.3
Tobacco abuse	305.1
Significant Incidental Findings:	
Arterionephrosclerosis	403.9

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

This 54-year-old male had open-water diver certification but had not made a dive in five years. He made a shallow dive for a relatively short period of time with a buddy. Upon surfacing, the decedent informed his buddy that he didn't feel well and then lost consciousness. He was pulled from the water and resuscitation was unsuccessful. The autopsy disclosed evidence of many natural disease processes. The blood alcohol level was nearly twice the legal limit for driving a car in many states.

DAN RECORD NO: 4196 **AGE:** 56 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Cardiac dysrhythmia	427.9
Due to: Coronary atherosclerosis, severe	414.0
Other significant conditions contributing to death but not resulting in the underlying cause:	
Left ventricular hypertrophy	429.3
Hypertension	401.9
Scuba diving	E910.1
Tobacco abuse (in past)	305.1
Elevated serum lipids	272.4
Significant Incidental Findings:	
Hypertensive renal disease	404.0

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

A very experienced, 56-year-old, male, dive instructor made a dive to 75 fsw for 40 minutes with a buddy. When they became low on air, the divers surfaced and began to swim back to the boat. During the surface swim, the divers became separated, and the decedent was found floating near the stern in full cardiopulmonary arrest. Resuscitation efforts were unsuccessful. The decedent had an apparent episode of atrial fibrillation one week earlier. The autopsy revealed extensive evidence of cardiovascular disease.

DAN RECORD NO: 5896 **AGE:** 40 **SEX:** F **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Cardiac dysrhythmia	427.9
Due to: Myocardial fibrosis	412.0
Other significant conditions contributing to death but not resulting in the underlying cause:	
Pulmonary edema	428.1
Scuba diving	E910.1

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

A 40-year-old female certified diver with less than 20 lifetime dives made a 66 fsw dive for a bottom time of 20 minutes. She was low on air and surfaced. While on the surface, the decedent began to struggle and complained of having difficulty breathing. The other divers came to her aid and ensured that her head did not go below the surface. The decedent became unresponsive, and resuscitation efforts were unsuccessful. A detailed autopsy revealed extensive myocardial fibrosis with involvement of the conduction system.

DAN RECORD NO: 6796 **AGE:** 59 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Acute myocardial infarction	410.9
Due to: Coronary atherosclerosis, severe	414.0
Significant Incidental Diagnoses	
Mucinous carcinoma of the appendix	153.5
Arterionephrosclerosis	403.9
Scuba diving	E910.1

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

A 59-year-old male who had open-water certification made a dive from his kayak without a buddy. The decedent tied a line from his boat to himself. After an extended period of time, someone from a passing boat pulled the line in with the lifeless diver attached. The decedent's primary air source was empty, but his spare was nearly full. The autopsy disclosed severe coronary artery disease and a ruptured plaque in the circumflex artery. There was also evidence of an acute myocardial infarction. The decedent had reportedly been taking beta blocker agents on a regular basis.

DAN RECORD NO: 6996 **AGE:** 46 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Cardiac dysrhythmia	427.9
Due to: Coronary atherosclerosis	414.0
Other significant conditions contributing to death but not resulting in the underlying cause:	
Tobacco abuse	305.1

Nortriptylene use	E939.0
Scuba diving	E910.1

Significant incidental diagnoses

Benign renal cyst	593.2

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

This 46-year-old, male, certified dive instructor made a dive to 95 fsw for 35 minutes. He and his dive buddy were following a slope of the bottom toward the surface when he signaled that he was ascending. The buddy stated that the decedent was in visible distress, and he was witnessed to spit out his regulator. The buddy was unable to release the decedent's weight belt, but he did manage to get the diver to the surface. Resuscitation was unsuccessful. The autopsy showed diffuse coronary artery disease and toxicology was positive for antidepressant medication.

DAN RECORD NO: 7196 **AGE:** 51 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Cardiac dysrhythmia	427.9
Due to: Coronary atherosclerosis	414.0

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

Scuba diving	E910.1

Significant Incidental Findings:

Atherosclerosis of the renal arteries	403.9

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

A very experienced, 51-year-old, male diver had a habit of diving alone to collect fish while his wife waited back in the boat. The decedent had a history of hypertension and took medication for allergies as well. After making a dive in a fairly strong current, he came along side the boat and told his wife that he was having difficulty breathing and was very fatigued. The diver's wife attempted to get a rope to him, but he quickly sank down beneath the surface before this could occur. The body was recovered one week later, and an autopsy showed severe coronary artery disease.

DAN RECORD NO: 7696 **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:

Hypertension	401.9
Left ventricular hypertrophy	429.3
Obesity	278.0
Toxicology positive for diphenhydramine	E933.0

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

This 51-year-old male was a student in an initial open-water certification course making his initial set of dives. During the first dive, the decedent surfaced with a nosebleed, but otherwise it was uneventful. The second dive was to 30 fsw and was fairly uneventful until the victim was seen to lose consciousness shortly after surfacing. The autopsy did not show any evidence of pulmonary barotrauma or air embolism. The medical examiner ascribed the cause of death to drowning, but the history and evidence of extensive natural disease makes a cardiac event more likely.

DAN RECORD NO: 8496 **AGE:** 53 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Cardiac dysrhythmia	427.9
Due to: Fibrous pericarditis	423.1

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

Cardiomegaly	429.3
Arterionephrosclerosis	403.9
Tobacco abuse	305.1

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

This 53-year-old male was a student in an initial open-water certification course and was making his final check-out dives before certification. He lost consciousness on the surface after an uneventful dive to 35 fsw. The decedent smoked two packs of cigarettes per day and used an albuterol inhaler. It is unclear what form of reactive airway disease he may have had. The autopsy disclosed 400 cc of fluid in the pericardial sac with dense fibrous pericardial adhesions. The decedent's equipment was in good working order, and the air in his tank was within standards.

Drowning Due to Insufficient Air

The following cases are placed together because they represent instances when running out of breathing gas directly resulted in the diver drowning. Cases where insufficient gas was only one of several factors contributing to the fatality, e.g., entrapment in a cave, have been placed in other categories. These nine fatalities occurred because the individual did not complete the dive with a sufficient reserve of breathing gas. Most dive training organizations recommend that divers be on the surface or on the boat with at least 300-500 psi in their tank as a margin of safety.

DAN RECORD NO: 1296 **AGE:** 32 **SEX:** M **DIVER CAT:** R/T

Cause of Death	**ICD-9-CM**
Immediate: Asphyxiation	799.0
Due to: Insufficient air	E913.2
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Panic	308.0
Morbid obesity	278.0
Left ventricular hypertrophy	429.3

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

This 32-year-old, male, certified diver was in a freshwater spring when he decided to enter a cave. The decedent had two years of diving experience, but no training in cave penetration. He found an air pocket within the cave and was witnessed to remove the regulator from his mouth, gasp for air and panic. His buddy attempted to get the decedent to take a regulator but without success. The decedent was pulled from the cave and could not be resuscitated at the surface. The medical examiner ascribed the cause of death to an air embolism based on bubbles within the cardiac veins. The occurrence of an air embolism is unlikely given the dive profile and details of the mishap.

DAN RECORD NO: 1796 **AGE:** 42 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Insufficient air	E913.2
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Coronary atherosclerosis	414.0
Diphenhydramine use (toxicology)	E933.0

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

This 42-year-old male was in his initial open-water certification course making the last of his required dives for certification. He had already made several uneventful dives during the past three days but had been having intermittent episodes of seasickness. When the decedent's buddy became low on air, the instructor took the buddy to the surface. The decedent did not surface with the other two divers, and other divers in the class came across him, face down in the sandy bottom. He was brought to the surface but could not be resuscitated. The autopsy was consistent with drowning. Examination of the decedent's equipment revealed a tank that contained 50 psi of air and 2500 cc of water.

DAN RECORD NO: 2496 **AGE:** 43 **SEX:** M **DIVER CAT:** R/T

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Insufficient air	E913.2
Due to: Scuba diving	E910.1
Significant Incidental Findings:	
Benign prostatic hypertrophy	600.0

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

This was the 43-year-old father of one of the cave fatality cases. This diver had less than 20 lifetime dives and no cave diving experience. The decedent made it out of the cave but then went back in to try to find his son. Unfortunately, he had little air left in his tank and lost consciousness upon returning to shore the second time. The results of the initial autopsy are not available, but a repeat autopsy showed changes consistent with drowning and no other significant disease processes.

DAN RECORD NO: 2796 **AGE:** 45 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Insufficient air	E913.2
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Left ventricular hypertrophy	429.3
Fatty liver	571.8

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

This 45-year-old male diver had moderate diving experience and advanced open-water certification. After an uneventful first dive, he and his dive buddies entered the water from shore to explore a sunken barge. Approximately 10 minutes into the dive, the decedent signaled to his buddies that he was low on air, and he headed back to shore alone. When the others completed their dive, the decedent could not be located. His body washed up on shore nine days later. The autopsy findings are consistent with drowning but other causes of death cannot be eliminated with certainty. The complete autopsy report is not available for review.

DAN RECORD NO: 6196 **AGE:** 32 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Insufficient air	E913.2
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Obesity	278.0
Panic	308.0

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

This 32-year-old, male, certified diver had no more than eight lifetime dives when he made a dive to 123 feet for 20 minutes. The decedent ran out of air and refused to buddy breathe but did accept his buddy's spare air. During the ascent, the decedent panicked and was last seen heading back to depth. The body was recovered two days later and a contributing factor was the 46 pounds of weight the decedent was wearing and did not drop during the ascent.

DAN RECORD NO: 7296 **AGE:** 49 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Insufficient air	E913.2
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Coronary atherosclerosis	414.0
Left ventricular hypertrophy	429.3
Toxicology positive for ethanol	305.0
Toxicology positive for benzodiazepam	E934.4

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

A 49-year-old, male, certified diver made a wreck dive to 70 fsw for 23 minutes. He signaled to his buddy that he was out of air but declined to share air. As they were ascending, the decedent lost consciousness and had to be towed to the boat. Resuscitation efforts were unsuccessful. The autopsy did not show evidence of pulmonary barotrauma or gas embolism. Evaluation of the equipment revealed a malfunctioning regulator that may have contributed to the decedent's difficulty while at depth.

DAN RECORD NO: 7796 **AGE:** 42 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Insufficient air	E913.2
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Obesity	278.0

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

This 42-year-old, male, certified diver went to 115 fsw with one buddy. Just prior to ascent, the divers signaled to each other that it was time to finish the dive. The decedent could not be located on the surface by his buddy, and the Coast Guard located the body later that day. The medical examiner concluded the cause of death to be drowning and no evidence of air embolism could be demonstrated at autopsy. An air embolism cannot be completely ruled out, especially since the diver had an empty tank.

DAN RECORD NO: 8296 **AGE:** 33 **SEX:** M **DIVER CAT:** R

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

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

A 33-year-old male, with moderate diving experience, was on a large dive boat but chose to dive alone in order to catch lobster. When the decedent did not return to the boat, a search was initiated, and he was found unconscious in a cavern at 50 fsw. An evaluation of the diver's equipment revealed that the BC would not hold air, and that his tank was empty. Additionally, the first stage was incorrectly attached which may have resulted in a large air leak. The autopsy was consistent with drowning.

DAN RECORD NO: 8596 **AGE:** 50 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Insufficient air	E913.2
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Cocaine use, recent (toxicology positive)	E980.4
Obesity	278.0
Pulmonary emphysema	492.8
Significant Incidental Findings:	
Fatty liver	571.8

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

A 50-year-old male with five lifetime dives had been certified for two months when he decided to make a series of dives with a small group of friends. During the first dive, the decedent finished with a nearly empty tank. He became separated from his buddy during the second dive after again running out of air. Another diver found him floating beneath the surface, unconscious and without his regulator in his mouth. Resuscitation efforts were unsuccessful. An evaluation of the decedent's equipment confirmed that he was out of air, and also revealed that his weights had been incorrectly attached so that the quick release mechanism would not operate.

Drowning / Accident

DAN RECORD NO: 496 **AGE:** 26 **SEX:** F **DIVER CAT:** R/T

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Panic	308.0

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

This 26-year-old, female, certified diver had made 25 to 30 lifetime dives, but they were all in warm water and to depths shallower than 80 fsw. She planned a dive in an extremely cold freshwater lake to visit a wreck that was at 140 feet. While at 70 feet during the descent down the anchor line, the decedent inexplicably spit her regulator out and panicked. Her dive buddy gave her his alternate air source (octopus), but she spit that out as well and began to drift away from the line. The buddy went to the surface for help, and two divers entered the water and found the decedent unconscious and on the bottom. She was brought to the surface where attempts at resuscitation were unsuccessful. The autopsy findings were consistent with drowning. An evaluation of the diver's equipment revealed 1800 psi in her tank, and all gear was in adequate working condition.

DAN RECORD NO: 1596 **AGE:** 38 **SEX:** M **DIVER CAT:** R

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

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

Coronary atherosclerosis, severe	414.0
Myocardial Infarction, remote	412.0
Pulmonary emphysema	492.8
Fatty liver	571.8
Tobacco abuse	305.1
Cerebral infarcts, multiple, small, remote	436.0

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

This 38-year-old male diver received his initial open-water certification during a five-day course six years ago and had not been diving since that time. He made a shore entry with his buddy and was noted to fatigue easily during the surface swim. After spending 30 minutes in 20 to 30 fsw, the decedent ran low on air, and the two divers surfaced. The dive buddy swam below the surface toward shore and noted that the decedent had removed his buoyancy compensator and was swimming along the surface with the BC as a float. The dive buddy could not find the decedent on shore, and a search was initiated. The BC was recovered that evening, but the decedent's body was not found until five days later. The autopsy disclosed numerous natural disease processes, and death due to a cardiac event cannot be conclusively ruled out.

DAN RECORD NO: 2896 **AGE:** 47 **SEX:** F **DIVER CAT:** R

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

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

Panic	308.0

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

This 47-year-old female had been certified for four months and had made 11 dives. She made a shore entry in rough seas for her first night dive. After a 15 minute dive to 31 fsw, the decedent surfaced and required assistance in getting back to shore. She became unconscious and was pulseless when they reached the shore. Cardiopulmonary resuscitation resulted in a transient return of the decedent's pulse, but further resuscitation efforts were unsuccessful. The autopsy findings were consistent with drowning.

DAN RECORD NO: 3196 **AGE:** 43 **SEX:** F **DIVER CAT:** R

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

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

This 43-year-old woman was in a scuba familiarization course, which included one pool session before an open-water dive. During the initial open-water dive, she was doing well except for becoming cold during the safety stop. No details are available on her exact problem on the surface, but she became unconscious and could not be resuscitated. The autopsy was consistent with drowning and did not demonstrate any evidence of significant natural disease processes.

DAN RECORD NO: 3496 **AGE:** 35 **SEX:** M **DIVER CAT:** R

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

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

Left ventricular hypertrophy	429.3

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

This 35-year-old male received his initial open-water certification just a few weeks earlier. He was making a shore entry dive with a group of divers in a rough surf zone. As the decedent walked into the surf, a strong riptide pulled him under and knocked off his mask and regulator. Lifeguards entered the water and pulled the diver to shore, but he could not be resuscitated. The autopsy findings were consistent with drowning.

DAN RECORD NO: 3596 **AGE:** 24 **SEX:** F **DIVER CAT:** R

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

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

This 24-year-old woman was participating in a scuba familiarization class that included an open-water dive after a very brief orientation to the equipment. This was her first lifetime dive, and she was reported to be somewhat nervous. At the end of the dive, which took place in 35 fsw, all of the other divers exited the water and removed their gear. It was not until the boat had returned to the pier that the decedent was noted to be missing. The boat returned to the dive site where the decedent was found unconscious and on the bottom. Resuscitation efforts were unsuccessful, and the autopsy findings were consistent with drowning.

DAN RECORD NO: 4796 **AGE:** 31 **SEX:** M **DIVER CAT:** R

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

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

A 31-year-old, male, certified diver with minimal experience made a shore entry dive in cold water with a buddy. After spending 50 minutes at 15 fsw, the two divers surfaced and attempted a surface swim back to shore. The decedent was struggling in the strong surface current which was reported to be up to four knots. The decedent disappeared below the surface, and his body was not recovered until one month later. The diver's weight belt was unsnapped but caught under the straps of the buoyancy compensator. No depth or pressure gauges were present, and the tank was empty. The autopsy findings were consistent with drowning.

DAN RECORD NO: 5196 **AGE:** 24 **SEX:** M **DIVER CAT:** U

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Panic	308.0
Hypothermia	991.6
Significant Incidental Findings:	
Arteriovenous malformation, brain	747.81

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

This 24-year-old male had no certification or documented prior experience with diving. He and another diver descended as a buddy team after a shore entry. The decedent experienced mask flooding, and the two divers surfaced so he could clear his mask. During the second descent, the divers stirred up the silt and became separated. The dive buddy went to get help, and the decedent's body was found 30 minutes later at 20 fsw. He was pronounced dead at a local hospital. The autopsy was consistent with drowning.

DAN RECORD NO: 6396 **AGE:** 35 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Coronary atherosclerosis, mild to moderate	414.0
Left ventricular hypertrophy	429.3
Panic	308.0
Significant Incidental Findings:	
Fatty liver	571.8
Atherosclerosis of the aorta, mild	440.0

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

This 35-year-old male was a divemaster but only had 31 lifetime dives and seven months of experience. He made a dive to 34 feet in a freshwater lake using a drysuit with two other divers. The decedent was experiencing equipment

problems and decided to abort the dive within the first few minutes. On the surface, he told his dive buddy that he was unable to inflate his buoyancy compensator. The buddy attempted to assist the decedent to shore, but they had difficulty making progress and the decedent slipped back beneath the surface. Several others assisted the diver to the beach where resuscitation efforts were unsuccessful. An equipment evaluation revealed that the decedent's low-pressure inflator hose was not connected to the buoyancy compensator and that he was likely overweighted. A cardiac event cannot be ruled out as possibly contributing to the fatality.

DAN RECORD NO: 6596 **AGE:** 37 **SEX:** M **DIVER CAT:** T

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

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

Coronary atherosclerosis, severe	414.0

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

A 37-year-old, very experienced, male diver made a quarry dive in cold water with a less experienced buddy. The decedent was using a mixture of helium, nitrogen and oxygen while his buddy used air. After spending 15 minutes at a maximum depth of 122 feet, the divers separated and, in accordance with the dive plan, the decedent stayed in the water while his buddy surfaced. When the decedent did not surface during the next two hours, a search was initiated and his body was recovered with the regulator still in his mouth. The autopsy findings were consistent with drowning, but the event leading to the drowning is unknown.

DAN RECORD NO: 7396 **AGE:** 36 **SEX:** M **DIVER CAT:** R

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

Significant Incidental Findings:

Hemangiomas in the liver, multiple	228.0

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

This 36-year-old male made a reportedly uneventful dive with a buddy. The decedent's certification level and diving experience are unknown. The two divers surfaced a long distance from the boat and with a strong current. They were unable to make it to the boat and became separated during the surface swim. The dive buddy eventually made it to shore and called for assistance. The decedent's body was recovered the next morning, and the autopsy findings were consistent with drowning.

DAN RECORD NO: 7496 **AGE:** 45 **SEX:** M **DIVER CAT:** R

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

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

This 45-year-old male diver was certified but had less than 10 lifetime dives. He and his buddy made a shore entry dive to 80 fsw for 15 minutes. The details of what occurred at depth are minimal, but the buddy surfaced rapidly to call for assistance and was treated for an air embolism. The decedent's body was found on the bottom an hour later and the autopsy showed no evidence of air embolism or significant natural disease processes.

DAN RECORD NO: 8396 **AGE:** 54 **SEX:** F **DIVER CAT:** R

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

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

Renal arteriolosclerosis	403.9

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

This 54-year-old woman with minimal diving experience was diving on a wreck in 90 fsw. The details of the incident are incomplete, but witnesses stated that the woman removed her regulator from her mouth while on the bottom. She was assisted to the surface by an instructor where resuscitative efforts were unsuccessful. The findings at autopsy were consistent with drowning. The woman also had severe arthritic changes in her hands, which would have made it difficult to handle equipment.

Drowning / Entrapment

DAN RECORD NO: 1096 **AGE:** 43 **SEX:** F **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Entrapment (lines)	E918.5
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Hypothermia	991.6
Panic	308.0

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

This 43-year-old female had received her open-water certification within the last six months when she and her husband planned a freshwater dive to recover a sunken snowmobile. They made four dives to greater than 100 feet in extremely cold water using a wet suit for thermal protection. The decedent was markedly overweighted and during the fourth dive both she and her husband became entangled in the ropes they were using to mark the snowmobile. Her husband was able to drop his weight belt and free himself, but the decedent was unable to do so. Neither diver carried a knife. The decedent's body was recovered three hours later, and there was still 1000 psi in her tank. The autopsy findings were consistent with drowning, but a cardiac dysrhythmia due to hypothermia cannot be excluded.

DAN RECORD NO: 3396 **AGE:** 30 **SEX:** M **DIVER CAT:** T

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Insufficient air	E913.2
Due to: Entrapment (cave)	E918.2
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Seizure disorder	780.3

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

A 30-year-old male who was a certified cave diver had a frequent habit of diving alone. Additionally, the decedent had epilepsy, for which he took Tegretol and phenytoin. His last seizure was 18 months earlier. One night he made a dive into a cavern that had a known depth of 260 feet. When the decedent did not return home that night, a search of his favorite dive sites turned up his vehicle with a line attached to the bumper and leading into the cavern entrance. Numerous cave divers searched for the body for the next several days, but it was not found until 8 months later. The decedent was wedged into a short branch off of the main cavern. An autopsy was performed for identification purposes only since the diver's remains were skeletonized. A seizure cannot be ruled out, but the decedent's tanks were empty making drowning after running out of air the most likely cause of death.

DAN RECORD NO: 3996 **AGE:** 29 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Entanglement (fishing net)	E918.9
Due to: Scuba diving	E910.1

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

This 29-year-old certified and experienced diver was in the water without a buddy in order to retrieve a fishing net. Approximately 10 minutes into the dive, the decedent became entangled in the net and could not extricate himself. A surface observer made attempts at a rescue, but he was limited because of a lack of scuba equipment. Rescue divers brought the decedent's body up one hour later. The autopsy was consistent with drowning.

DAN RECORD NO: 4296 **AGE:** 39 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Insufficient air	E913.2
Due to: Entanglement (rope)	E918.5
Due to: Scuba diving	E910.1

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

Panic	308.0

Significant Incidental Findings:

Prosthetic lower extremity	736.9

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

A very experienced 39-year-old male with rescue diver certification made a series of two dives on a wreck. After an uneventful first dive, he reportedly began the second dive with approximately 1000 psi of air. During the dive, the decedent ran out of air and needed to use his buddy's alternate air source. Entanglement in the anchor line and panic contributed to the bad outcome of this dive. Cardiopulmonary resuscitation was performed on the surface, but the diver was pronounced dead at a local hospital.

DAN RECORD NO: 5496 **AGE:** 17 **SEX:** M **DIVER CAT:** U

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

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

Contusion, side of head	920.0

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

This 17-year-old male had no documented training in scuba diving but borrowed equipment from a friend to enter a lake and collect mussels. Witness statements are inconsistent about whether he had a dive buddy, but it seems likely that he entered the water alone with a rope around his waist which was attached to a dive flag. Approximately 30 minutes into the dive, friends on the surface noticed an absence of bubbles, and, when they pulled on the rope, the diver appeared to be caught on the bottom. They finally pulled him up, unconscious and without his dive gear. Resuscitation efforts were unsuccessful.

DAN RECORD NO: 5796 **AGE:** 33 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Insufficient air	E913.2
Due to: Entrapment (kelp)	E918.0

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

Depressive disorder	296.2
Antidepressant medication	E939
Panic	308.0

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

This 33-year-old, male, advanced open-water student with 20 lifetime dives made a series of three dives to 33 fsw. The decedent's buddy was a 15-year-old male who became low on air during the third dive. The divers shared the decedent's air source until he pulled it away from his buddy and they separated. The decedent's body was recovered in 30 fsw, partially entangled in kelp. The decedent's tank was empty, and the autopsy findings were consistent with drowning. Toxicology was positive for a prescription antidepressant medication and its metabolites.

DAN RECORD NO: 6296 **AGE:** 26 **SEX:** M **DIVER CAT:** R/T

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

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

Coronary atherosclerosis, mild	414.0
Left ventricular hypertrophy	429.3
Scalp contusion	920.0
Nitrogen narcosis	293.0

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

This 26-year-old male was a certified open-water diver but had only recently enrolled in a cave diving class. He and a friend made two dives in a freshwater spring that contained a cavern leading to a cave. The first dive was to 130 feet for 30 minutes and was uneventful. After a two-hour surface interval, the two divers went back in, and this time the decedent entered the cave section without a guide rope. He apparently made a wrong turn and ended up in a false chimney. In an attempt to extricate himself, the diver ditched his equipment but still did not make it out of the cave. The dive buddy returned to the surface to get help after losing sight of the decedent. Specially trained rescue divers recovered the body the next day.

DAN RECORD NO: 6696 **AGE:** 43 **SEX:** F **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Insufficient air	E913.2
Due to: Entrapment (kelp)	E918.0
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Panic	308.0

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

This 43-year-old female had been certified for one year when she made a night dive with a large group of divers. She apparently became entangled in kelp when she surfaced to see where the boat was. The decedent panicked and failed to drop her weight belt. She became unconscious and resuscitation efforts were unsuccessful. An equipment check revealed that the decedent was out of air and her buoyancy compensator would not hold air. The autopsy findings were consistent with drowning.

Death While Diving — Miscellaneous

DAN RECORD NO: 5996 **AGE:** 39 **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: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Multiple trauma	959.8
Incidental Findings:	
Left ventricular hypertrophy	429.3

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

This 39-year-old, male, dive instructor was taking a class of students on one of the required dives for initial open-water certification. For reasons that have not been entirely explained, the instructor entered the water while the propeller was turning and the boat was still moving. He was struck in the head by the propeller and was assisted back into the boat where he became unconscious. The decedent was taken to the closest medical treatment facility where he was pronounced dead upon arrival. Toxicology revealed a blood alcohol of 12 mg/dL, which can be from either postmortem decomposition or alcohol use the previous night.

Medical Condition

DAN RECORD NO: 1196 **AGE:** 46 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Respiratory insufficiency	786.09
Due to: Asthma	493.9
Other significant conditions contributing to death but not resulting in the underlying cause:	
Scuba diving	E910.1

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

A 46-year-old male with a lifelong history of asthma was a certified diver but hadn't made a dive in 20 years. His medications included Theophylin and Ventolin, and he had complained of a recent exacerbation of his symptoms. The decedent made a seemingly uneventful dive to 30 feet for 30 minutes and surfaced apart from the group. On the surface, the diver began to struggle, and those that assisted him stated that he was noticeably wheezing. By the time he was brought into the boat, the decedent was in cardiopulmonary arrest and resuscitation efforts were unsuccessful. The forensic pathologist ascribed the death to status asthmaticus.

DAN RECORD NO: 3696 **AGE:** 51 **SEX:** F **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Acute pulmonary edema	508.9
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Coronary atherosclerosis, moderate	414.0
Antidepressant medication	E939.0
Significant incidental diagnoses	
Cerebrovascular disease, mild	437.0
Uterine leiomyomas	218.1

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

This 51-year-old female certified diver with significant diving experience made a seemingly uneventful, short, shallow dive with her husband. On the surface, she became increasingly short of breath, and eventually the decedent's husband inflated her buoyancy compensator and towed her to the boat, making sure to keep her head above water. The decedent's breathing problems continued on the boat, and she eventually lost consciousness and could not be resuscitated. The autopsy disclosed evidence of both cardiovascular disease and changes consistent with drowning. This may have been a primary cardiac event, but a simple drowning is unlikely, given the sequence of events as described by the husband. There was no evidence of pulmonary barotrauma or embolism noted at autopsy. Acute pulmonary edema is uncommon during a dive, but it does occur.

Autopsied Cases — Report Not Available

In general, DAN has an excellent relationship with medical examiner offices, and their cooperation is essential in making these case histories available to the public. DAN receives timely autopsy and accident reports on a majority of the diving fatalities. In every case, confidentiality regarding names and specific locations is maintained. There were 11 diving fatalities reported in 1996 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 increasing litigious environment surrounding diving fatalities has resulted in less information being made available on U.S. fatalities as well.

Air Embolism

DAN RECORD NO: 1996 **AGE:** 43 **SEX:** F **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Air embolism	958.0
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Obesity	278.0

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

This 43-year-old female was making her first dive after receiving initial open-water certification one week earlier. She was morbidly obese but otherwise had no known health problems. After 48 minutes at a maximum depth of 40 fsw, she and her husband began their ascent. The decedent was coughing and having noticeable difficulty breathing during the ascent. At the surface, she complained of tightness in her chest and difficulty with breathing. The diver had frothy fluid coming from her nose and mouth, and she rapidly became unconscious. The decedent was quickly transferred to a recompression chamber, but resuscitation efforts were unsuccessful, and she died before hyperbaric oxygen therapy could be initiated. An autopsy was performed, but the findings were not released. This death could just as easily have been due to pulmonary edema or a cardiac event.

Cardiovascular Disease

DAN RECORD NO: 796 **AGE:** 49 **SEX:** M **DIVER CAT:** R/T

Cause of Death	**ICD-9-CM**
Immediate: Ventricular Fibrillation	427.41
Due to: Coronary atherosclerosis	414.0
Other significant conditions contributing to death but not resulting in the underlying cause:	
Left ventricular hypertrophy	429.3

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

A 49-year-old certified diver with a moderate amount of experience made a dive on a wall to a maximum depth of 159 fsw. He had a history of mild hypertension, but was otherwise healthy. Most of the dive was spent at a depth of 100 to 120 fsw, and the decedent's buddies reported that he seemed fatigued. The decedent surfaced while the other two divers made decompression stops, and witnesses stated that he did not appear in any distress. The diver became unconscious on the surface, and resuscitation efforts, including ACLS (advanced cardiac life support), were unsuccessful. An autopsy was performed, but the report was not released.

DAN RECORD NO: 8196 **AGE:** 40 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Cardiac Dysrhythmia	427.9
Due to: Coronary atherosclerosis	414.0
Other significant conditions contributing to death but not resulting in the underlying cause:	
Scuba diving	E910.1

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

This 40-year-old male had significant diving experience but was an infrequent diver and had not been diving in the past year. He was diving with his son in a remote location when witnesses observed him having some difficulties while on the bottom. At one point, the decedent did not have his regulator in his mouth, and other divers assisted him to the surface. The diver lost consciousness and was unable to be resuscitated back on the boat. The autopsy report is unavailable, but the cause of death was listed as a drowning due to a cardiac event.

Death While Diving — Miscellaneous

DAN RECORD NO: 996 **AGE:** 31 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Head trauma, open	854.1
Due to: Struck by boat	E838.5
Due to: Scuba diving	E910.1

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

A 31-year-old male with a moderate amount of diving experience made a dive to approximately 40 fsw with two friends. The decedent became separated from his buddies and was not found until two hours later, when his body was discovered on the bottom of the swimming area. The decedent had been struck in the head by a boat propeller and was pronounced dead at the scene. No autopsy report is available.

DAN RECORD NO: 4396 **AGE:** 34 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Asphyxia	799.0
Due to: Aspiration/Vomiting	933.1
Due to: Exhaustion due to excess exertion	994.5
Other significant conditions contributing to death but not resulting in the underlying cause:	
Obesity	278

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

A 34-year-old, male, certified diver, with less than 15 lifetime dives, made a shore entry with three other divers. This was the second dive of the day, and all divers had eaten a large meal for lunch. The decedent became low on air and separated from the group to head back to shore. Upon reaching shore, the decedent stood up and then quickly collapsed. Resuscitation efforts by others on the beach were unsuccessful. The death certificate attributes the diver's demise to aspiration. An autopsy was performed, but the report is not available.

Drowning / Accident

DAN RECORD NO: 4096 **AGE:** 58 **SEX:** M **DIVER CAT:** R

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

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

Obesity	278

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

This 58-year-old male had 12 lifetime dives and was on a live-aboard dive boat with a large group. During the second day of diving, the decedent left the group to return to the boat when his gauge read 1000 psi remaining. When he did not return with the other divers, a search was initiated, and the decedent was found on the bottom 30 minutes later. An autopsy was performed, but the findings are unavailable. The death certificate states the cause of death as drowning, but a cardiac event cannot be excluded.

DAN RECORD NO: 4896 **AGE:** 52 **SEX:** F **DIVER CAT:** R

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

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

Tobacco abuse	305.1

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

This 52-year-old female was a certified diver, with minimal experience, participating in an advanced open-water course. As part of the course, the decedent made a night dive using a shore entry. The group of divers were at 15 fsw when the instructor surfaced to assess their location relative to the shore. The instructor noted one of his students on the surface calling for assistance with his dive buddy. The decedent was found unconscious in 9 fsw and resuscitation efforts were unsuccessful. An autopsy was performed, but the findings are unavailable.

DAN RECORD NO: 4996 **AGE:** 24 **SEX:** F **DIVER CAT:** R

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

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

A 24-year-old female with nine lifetime dives was a student in an advanced open-water certification course. She frequently had difficulty equalizing pressure in her middle ears and had to descend slowly. During a night dive on a wreck, the current was fast enough that the divers were instructed to descend alone and meet at the wreck. Visibility was extremely poor. The decedent and her buddy separated during the descent, and she did not return with the others at the end of the dive. The body was recovered in 80 fsw the next morning. An evaluation of the equipment revealed that the tank was empty, and the low-pressure inflator hose was not attached to the buoyancy compensator. The autopsy report was unavailable, but the cause of death was listed as drowning.

Drowning / Entrapment

DAN RECORD NO: 2396 **AGE:** 21 **SEX:** M **DIVER CAT:** R/T

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

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

Panic	308

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

This 21-year-old inexperienced diver with open-water certification and no cave diving experience entered a cave with his father. They reportedly had some difficulty with orientation, and the silt significantly compromised visibility. The decedent was unable to find his way out of the cave, and his body was recovered an hour later by an experienced cave diver. An autopsy was performed, but the results are not available.

DAN RECORD NO: 4496 **AGE:** 31 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Entrapment (trees, brush)	E918.4
Due to: Scuba diving	E910.1

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

A 31-year-old male made a dive in an attempt to salvage a boat from the bottom of a lake. No information is available regarding the decedent's experience level. He apparently became entangled in submerged trees and brush, and drowned. If an autopsy was performed, the findings are unavailable to the public.

Drowning / Insufficient Air

DAN RECORD NO: 8096 **AGE:** 30 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Insufficient air	E913.2
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Asthma	493.9

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

There is limited information available on the death of this 30-year-old male who was an experienced diver. He became separated from his buddy in heavy surf and ran out of air. The body was recovered three weeks later. The decedent had a history of asthma, allergies, and vascular headaches. The pathologist who performed the autopsy concluded the cause of death to be asphyxia, possibly due to drowning or an asthma attack. The autopsy report was not released.

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 the manner of death are often clarified or confirmed by the findings of a postmortem examination. At least initially, all diving-related fatalities should be considered non-natural deaths. Only a complete investigation, including the performance of a thorough postmortem examination, will reveal whether the death was natural or accidental.

Diving deaths cause tremendous psychological trauma to families and survivors. They may receive some solace and a better understanding of the event with full disclosure of the details of the injury or illness. It is very important to answer the family's questions fully, making it clear how and why the diver died to the best of the investigator's knowledge.

There are legal reasons for performing an autopsy. Frequently, life insurance benefits are determined by the autopsy findings, such as the double indemnity provision with many policies in cases of accidental death.

Scuba-diving deaths are occasionally the basis for a lawsuit. Additionally, the victim is often young and otherwise healthy. A thorough autopsy provides evidence of fact and medical opinion that will be introduced into legal proceedings. The autopsy report must be carefully written in order to avoid the suggestion of error by anyone, when, in fact, no error is known to exist.

Air Embolism

DAN RECORD NO: 596 **AGE:** 36 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Air embolism	958.0
Due to: Rapid ascent	E902.2
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Panic	308.0
Nitrogen narcosis (possible)	293.0

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

Little information is available on the death of this 36-year-old male with advanced open-water certification. He was an infrequent diver who was making a dive to 130 fsw to explore a wreck with a divemaster and one other diver. The divemaster stated that he physically restrained the decedent during two attempted rapid ascents. The diver had plenty of air left in his tank, but it is possible that he had a malfunctioning regulator. After the second rapid ascent, the decedent was unconscious upon reaching the surface. An autopsy was not performed.

DAN RECORD NO: 5396 **AGE:** 32 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Air embolism	958
Due to: Rapid ascent	E902.2
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Asthma	493.9

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

This 32-year-old male was advanced open-water certified but an infrequent diver. He made a deep dive with a large group but had no designated buddy. The decedent was photographing sea life and went to 90 fsw for 25 minutes. Witnesses stated that he took their photograph at 30 fsw during the ascent and was next seen on the surface and unconscious. No information is available regarding whether an autopsy was performed or not.

DAN RECORD NO: 5596 **AGE:** 26 **SEX:** M **DIVE CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Anoxic brain injury	348.1
Due to: Air embolism	958.0
Due to: Rapid ascent	E902.2
Due to: Scuba diving	E910.1

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

This 26-year-old male diver was a student in an advanced open-water course. He made a shore entry dive to 102 feet for a bottom time of 28 minutes along with two other divers. After running a little low on air, the decedent ascended to a safety stop where he paused briefly before going directly to the surface. The other divers described the decedent's ascent as rapid. He was progressively short of breath on the surface and then abruptly arrested. The diver received recompression therapy for three days before being pronounced brain dead. An equipment evaluation showed 900 psi remaining in the decedent's tank, but his equipment was in poor repair. Organs were procured for donation, but an autopsy was not performed.

Cardiovascular

DAN RECORD NO: 6496 **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:	
Obesity	278.0
Accident due to water sports activity	E910.1

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

This fairly experienced, but infrequent, 51-year-old male diver was diving alone from a shore entry to do some spearfishing. He spent approximately 30 minutes at 30 fsw, and there were no witnesses to the fatal event. The decedent's body was noticed floating near the dock by a passing tour boat. His buoyancy compensator was inflated and a 37-pound weight belt was still in place. Resuscitation efforts were unsuccessful, and the diver was pronounced dead at a local hospital. An autopsy was not performed.

DAN RECORD NO: 6896 **AGE:** 61 **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:	
Scuba diving	E910.1

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

This 61-year-old male was an extremely experienced diver who had logged over 1000 dives. After a dive to 110 fsw for 10 minutes, he surfaced unconscious and without vital signs. Little information is available on the circumstances regarding this fatality, and an autopsy was not performed. The other most likely cause of death, an air embolism, would be unusual in such an experienced diver.

Drowning / Accident

DAN RECORD NO: 5096 **AGE:** 29 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Panic	308.0

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

A 29-year-old male with advanced open-water certification planned a decompression dive to 100 fsw to explore a wreck with three other divers. The decedent was using a recently acquired wetsuit and arranged three tanks, all filled with air, attached to three separate regulators, as his gas supply. Within minutes of reaching the bottom, the decedent signaled to his buddy that he was out of air. The two divers began to share air and ascend, but the decedent spit the octopus regulator out twice during the ascent. He lost consciousness before reaching the surface. CPR was performed for nearly an hour, and the diver was pronounced dead at a local hospital. An autopsy was ordered by the coroner, but it was never performed. Toxicology was also not performed. Unfortunately, the decedent's equipment was ditched during the rescue and was not recovered for testing. Evidence upon which the cause of death is based is minimal, and an air embolism may have been the cause of death.

Drowning / Entrapment

DAN RECORD NO: 7896 **AGE:** 43 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Drowning	994.1
Due to: Entrapment/Entanglement	E918
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Panic	308
Obesity	278

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

This 43-year-old male diver had received his initial open-water certification three months earlier and had made only three dives since finishing the course. He and a buddy entered a freshwater lake to do some spearfishing, but they became separated when the buddy became entangled in fishing line. When the decedent's buddy surfaced, he was unable to see bubbles and locate his dive partner. After searching in the area where they became separated, the decedent's buddy went for help. After a two-day search by rescue divers, the body was found entangled in fishing line at a depth of 80 feet. The decedent did not have a dive knife and had his weight in the pockets of his buoyancy compensator. An autopsy was not performed.

Drowning / Insufficient Air

DAN RECORD NO: 3896 **AGE:** 37 **SEX:** F **DIVER CAT:** R

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

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

Obesity	278.0
Panic	308.0

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

A 37-year-old, female, certified diver had made approximately 25 dives during her initial year of certification. She made a dive to 90 fsw in cold water for the purpose of collecting shellfish. The decedent was wearing a newly acquired and poorly fitting drysuit as well as a weight system with which she was unfamiliar. She had significant buoyancy problems during the entire dive. Witnesses stated that she appeared anxious and stressed. The decedent ran out of air and was assisted by her buddy until his air source became low. While the dive buddy arranged to use his backup air source, the two divers became separated. Another diver on the surface went back in the water to retrieve the decedent and resuscitation efforts were unsuccessful. An autopsy was not performed.

Bodies Not Recovered

Each year there are cases where diving fatalities occur, but a body is never recovered. There were four such cases in 1996. In a few instances, the circumstances surrounding the mishap are known. Most often, the final events of the dive are not known.

DAN RECORD NO: 1896 **AGE:** 30 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Death, unknown cause (body not found)	799.9
Due to: Scuba diving	E910.1

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

This 30-year-old certified dive instructor with over 2000 lifetime dives became separated from his buddy while diving on a wall at 120 fsw. The buddy surfaced and found the decedent's mask floating in the water. The body was never recovered despite an intense search lasting several days.

DAN RECORD NO: 4596 **AGE:** 23 **SEX:** M **DIVER CAT:** R/T

Cause of Death	**ICD-9-CM**
Immediate: Death, unspecified cause (body not recovered)	799.9

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

Nitrogen narcosis	293

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

This 23-year-old, male, dive instructor planned a dive to 300 fsw on air with two other divers. There was a very strong current, and the other two divers turned back at 50 fsw. The decedent continued to descend and was never seen again. Narcosis is only presumed to have been a factor once the diver reached an excessive depth.

DAN RECORD NO: 5296 **AGE:** 37 **SEX:** M **DIVER CAT:** R

Cause of Death	**ICD-9-CM**
Immediate: Death, unspecified cause (body not recovered)	799.9

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

This 37-year-old male was an experienced diver who made a shore entry dive without a buddy. The body was never recovered.

DAN RECORD NO: 7096 **AGE:** 32 **SEX:** M **DIVER CAT:** T

Cause of Death	**ICD-9-CM**
Immediate: Death, unknown cause (body not recovered)	799.9
Due to: Scuba diving	E910.1

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

This 32-year-old male was a dive instructor who had mixed gas certification. He planned a mixed gas dive to 450 fsw with an equally experienced buddy in order to view a wreck. The divers used a descent line and arrived at the planned depth with the buddy ahead of the decedent. When the buddy turned to begin his ascent, he saw the decedent approximately 50 to 60 fsw above him before losing visual contact. When the dive buddy arrived at the first decompression stop, the decedent was nowhere to be found. Safety swimmers went down to search for the lost diver, but their efforts were unsuccessful. The body was never recovered.

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: 296 **AGE:** 40 **SEX:** M **DIVER CAT:** U

Cause of Death	**ICD-9-CM**
Immediate: Death due to unknown causes	994.1
Due to: Scuba diving	E910.1
Other significant conditions contributing to death but not resulting in the underlying cause:	
Nitrogen narcosis	293.0

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

Little information is available about the circumstances surrounding the death of this 40-year-old male who had no known diving certification. He apparently was spearfishing at a depth greater than 200 fsw. The newspaper quotes the coroner as attributing the cause of death to "an embolism to the heart," but there is no autopsy report or witness statements available to substantiate that conclusion.

DAN RECORD NO: 2096 **AGE:** 45 **SEX:** M **DIVER CAT:** R/T

Cause of Death	**ICD-9-CM**
Immediate: Death due to unknown cause	798.9
Other significant conditions contributing to death but not resulting in the underlying cause:	
Scuba diving	E910.1
Insufficient air	E913.2

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

This 45-year-old male diver was certified but had logged less than five open-water dives. He made a dive in a lake without a buddy while friends waited back in the boat. The water depth was 250 feet at the location of the dive. At the end of the dive, the decedent surfaced away from the boat and appeared to be having problems. He submerged before assistance could be rendered and could not be located. The body was recovered five months later using a remote-controlled vehicle and camera. The decedent's valve stem on his tank was loose, and the tank was out of air. No further information is available on this case, and the cause of death could be a cardiac event, an air embolism or simple drowning.

Summary

DAN presents these fatality reports each year to be used as an instructional device for all divers, from novice to seasoned veteran. Nearly every fatal-diving scenario has a take home message or lesson to be learned that hopefully will prevent future similar outcomes. A majority, though not all, of these 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 diving planned, including advanced training for more challenging types of diving;
- Mentally and physically prepared to make the dive with enough physical reserve and training to handle changing diving 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 diving fatality include: dive experience and training, pre-existing health problems, level of physical fitness, and the influence of alcohol and 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. Caruso, JL, et al. Fatalities Related to Cardiovascular Disease in the Recreational Diving Population. Undersea and Hyperbaric Medicine, 24 (supp): 26, 1997.
5. National Center for Health Statistics, U.S. Public Health Service, DHHS.
6. 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.
7. 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 Doctors 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 (not recommended), eyewitness accounts will be invaluable. Questions to be asked include:

- When did the diver begin to have a problem (pre-dive, descent, bottom, ascent, post-dive)?
- 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 exist in one of the standard forensic pathology texts [2].
- The carotid arteries should be tied off immediately upon opening the chest.
- 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

* *Note: The name* Report on Diving Accidents and Fatalities *was changed to* Report on Decompression illness and Diving Fatalities *with the reporting of 1995 data in the report published in 1997.*

gas if practical. After the mediastinum, heart and great vessels have been examined underwater 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 person with diabetes, 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 skull 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. Alternatively, the brain may be removed prior to opening the chest, if desired.
- Have an expert evaluate the dive gear. Are the tanks empty? If not, the gas should be analyzed for purity (i.e., is carbon monoxide present?). 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 offgassing 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.

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 1980 to 1996 in Foreign Areas

	80-89	90-92	1993	1994	1995	1996	Totals
Anguilla	1						1
Antigua	1						1
Australia	2			1			3
Bahamas	19	6	1	7	6	2	41
Barbados	2					1	3
Bequia		1					1
Bermuda	1	1					2
Belize	4	1				2	7
British Virgin Islands	4			1			5
Canada	6	1					7
Caribbean Area		2					2
Cayman Islands	5	2	2	3	1	3	16
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	6	62
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					1	3
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					1	3
Unknown	1						1
Totals	**105**	**47**	**12**	**20**	**15**	**16**	**215**

Fatality Location Tables

U.S. Fatalities from 1980 to 1996 by State

State	80-89	90-92	1993	1994	1995	1996	Totals
Alabama	2	1		2			5
Alaska	9	2		1		1	13
Arizona	4			1			5
Arkansas	8	1		1	4		14
California	155	39	15	11	14	11	245
Colorado							
Connecticut	9	1			2		12
Delaware	3	1	1				5
Florida	231	58	27	25	22	18	381
Georgia	11	1		1		1	14
Hawaii	54	8	7	1	3	9	82
Idaho	4						4
Illinois	3	1			1		5
Indiana	1	1			1		3
Iowa		2					2
Kansas							
Kentucky	1					1	2
Louisiana	5	3	1		2	1	12
Maine	8	5		1		2	16
Maryland	1			1			2
Massachusetts	32	5	3	4	5	2	51
Michigan	12	2	2	2	2	1	21
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	1	6
New Hampshire	4						4
New Jersey	15	11	1	3	2	1	33
New Mexico	4	2		1	1		8
New York	21	10	3	2	2	2	40
North Carolina	12	3			2	3	20
Ohio	6	2		1		1	10
Oklahoma	1		1			1	3
Oregon	11	2	3				16
Pennsylvania	7	10	1	2	2		22
Rhode Island	19	4			2	2	27
South Carolina	3		1	1			5
South Dakota		1					1
Tennessee	4	2			1		7
Texas	19	4	2	1	2	1	29
Utah	5	1			1		7
Vermont	1						1
Virginia	5		1	1		2	9
Washington	67	8	2	6	10	4	97
West Virginia		1		1	1		3
Wisconsin	10	3	2	1	2	2	20
Wyoming	2						2
Washington DC							
Totals	**788**	**203**	**74**	**72**	**86**	**67**	**1290**

Fatality Location Tables

U.S. Fatalities from 1980 to 1996 by U.S. Territory

U.S. Territory	80-89	90-92	1993	1994	1995	1996	Territory Totals
Guam				3	2		5
Marshall Island				2			2
Puerto Rico	5	1				1	7
Virgin Islands	11	3	6	2	1	1	24
Totals	**16**	**4**	**6**	**7**	**3**	**2**	**38**

To report an injury, a fatality, or a near-miss in diving, call DAN's Medical Department at +1-919-684-2948

Divers Alert Network
The Peter B. Bennett Center
6 West Colony Place
Durham, NC 27705

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 non-alcoholic 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 — "Chemical Substances")
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 antidepressants, antianxiety agents and other related compounds.

Organic bases — includes pentazocine, methaqualone, cocaine and metabolites, propoxyphene, strychnine, methadone, ethclorvynol, quinine, 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

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. 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, a 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.

"Enriched-air nitrox" (EAN) is a mixture of oxygen/nitrogen other than the 20.9/78 percent mixture in 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 more often than mixed-gas diving. Both are controversial, because prior to recent years, mixed gas was used solely in commercial, military, and scientific diving 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, of Key Largo, Fla., 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 1996, there were a total of 11 nitrox or mixed-gas certifying agencies in North America.

The growing popularity of nitrox — referred to as "Enriched Air Nitrox (EAN)" in recreational diving, and mixed-gas diving has encouraged DAN to produce a brief analysis of the limited injury data available on recreational mixed-gas diving.

In previous years there were not enough cases for meaningful analysis to collect and follow up on mixed-gas diving injuries. Between 1990 and 1993 DAN recorded only 21 cases. In 1994, 10 cases were sent in to DAN and in 1995, 16 cases were sent to DAN.

The 1996 data is based on 23 scuba certified divers using nitrox or mixed gas who were injured and required treatment in a hyperbaric chamber. All types of mixed-gas diving will be referred to as "mixed gas" in this appendix. In the past three years, there have been seven recreational deaths where the divers were using mixed gas. In 1996, there were two deaths; three occurred in 1995; and two happened in 1994 using mixed gas. These 1996 fatality cases are included in the fatality appendix of the report (Appendix A, Pages 80-109).

There was an increase in the number of EAN and mixed-gas divers contacting DAN for advice and consultation. A total of 51 calls were made to the emergency line regarding EAN and mixed-gas diving. Thirty-two of these divers reported symptoms consistent with decompression sickness, and 12 divers were treated with hyperbaric therapy. At least two divers refused treatment. One diver endured symptoms over one month before calling. The largest group of callers were those on various oxygen percentages of EAN, included 21 divers with symptoms consistent with DCS. Other calls related to symptoms of the flu, ear and sinus barotrauma problems, and one non-emergency flying after diving on EAN question.

There is no way of determining incidence results. This is because there is no way of knowing how many mixed-gas or EAN divers participate in diving each year and how many dives are performed.

While IANTD reports certifying approximately 17,780 U.S. nitrox divers from 1985 to 1996, 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 14 of the 23 cases (61 percent) occurring in Florida. One case each was reported in Hawaii, New Jersey, Massachusetts, New York, North Carolina, Oregon and Rhode Island. There were two deaths outside the U.S., in the Cayman Islands and Canada.

Diver Characteristics

Divers trained in the use of nitrox and mixed gases *do* differ from air divers in the amount of specialized training they receive and in the operational procedures they are required to follow when using oxygen-enriched diving mixtures. EAN and mixed-gas divers should also be well informed about the potential for oxygen toxicity, a risk rarely encountered by a diver using compressed air.

In the 1996 injury population, there were two divers who used a nitrox mix with oxygen concentrations of greater than 40 percent oxygen; two were using an 80 percent mix as their decompression stop gas mix.

Two divers in this population were diving with trimix (a mixture of oxygen, nitrogen and helium) and three were diving a heliox mix (Table E.1, below). As seen in Table E.1, not all of the divers using mixed gas were certified in its use. In fact, eight divers (34.8 percent) were uncertified in mixed-gas diving and procedures.

The gas mix used by the two divers who died in 1996 was nitrox, trimix (oxygen, nitrogen and helium) and heliox (oxygen and helium). Both of these divers were certified in the use of mixed gases.

It is difficult to draw any conclusions about EAN 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 EAN or mixed-gas divers.

The largest fraction of mixed-gas divers (60.8 percent) are in the 30-39 year age range. In contrast, air divers are more evenly distributed over the 25-49 year age range (Table E.2, Page 119). EAN or mixed-gas certification often requires an advanced diver certification, which might exclude many younger divers.

Males dominate the mixed-gas population, with 87 percent of all cases involving men, compared to 64 percent males in air-diving injuries. (Table E.3, Page 119).

Table E.1 ***Mixed-Gas Certification by Gas Mix***

Gas Mix	Certified	Non-certified
Nitrox (29%-37%)	11	2
Nitrox (> 40%)	0	2
Nitrox (80%-decompression stop mix)	2	0
Nitrox and Trimix	1	0
Trimix (O_2-N_2-He)	1	1
Heliox (O_2-He)	0	3
TOTALS	**15**	**8**

Certification is based on having a certification as a mixed gas or technical diver.

Because most EAN and mixed-gas divers generally have an advanced certification, it is not surprising to find that a majority of these injury cases were certified at the advanced or instructor level (Table E.4, below). In contrast to air-diving injuries almost all injuries in mixed-gas divers occurred in divers with more than 121 lifetime dives. Twelve (52.2 percent) of the divers had been diving for 10 years or more, and no divers had been diving for less than two years (Table E.5, Page 120, top).

Table E.2 *Age Distribution of Nitrox or Mixed-Gas Injury Cases*

Age	1996 Percent	1995 Percent
20-24	8.7	18.8
25-29	17.4	31.3
30-34	30.4	18.8
35-39	30.4	18.8
40-44	8.7	12.5
45-49	4.3	--
TOTALS	**100.0**	**100.0**

Table E.3 *Sex of Nitrox or Mixed-Gas Injury Cases*

Sex	1996 Percent	1995 Percent
Female	13.0	12.5
Male	87.0	87.5
TOTAL	**100.0**	**100.0**

Table E.4 *Certification Level of Nitrox or Mixed-Gas Injury Cases*

Certification	Male	Female	Totals	1996 Percent	1995 Percent
Instructor	8	1	9	39.1	43.8
Divemaster	5	0	5	21.7	6.3
Advanced	3	1	4	17.4	37.5
Other	3	1	4	17.4	6.3
Basic/Open	1	0	1	4.3	6.3
TOTALS	**20**	**3**	**23**	**100.0**	**100.0**

Table E.5 *Diver Experience Among Nitrox or Mixed-Gas Injured Divers*

Male/Female	Total Lifetime Dives							
Years Diving	0-20	21-40	41-60	61-80	81-100	101-120	121+	TOTAL
2-3	1	0	1*	1/1*	0	0	2	6
4-5	0	0	0	0	0	0	0	0
6-7	0	0	0	0	0	0	1/1*	2
8-9	0	0	0	0	0	0	3	3
10-11	0	0	0	0	0	0	2	2
12-13	0	0	0	0	0	0	2	2
14-15	0	0	0	0	0	0	2	2
16-17	0	0	0	0	0	0	1	1
18-19	0	0	0	0	0	0	2	2
20-21	0	0	0	0	0	0	3	3
TOTALS	**1**	**0**	**1**	**2**	**0**	**0**	**19**	**23**

** Female divers*

Decompression Illness in Mixed-Gas Divers

Decompression illness is the general term for arterial gas embolism (AGE) and decompression sickness (which includes DCS I and DCS II).

In this population, no AGE cases were reported. This finding would not be unexpected, since this group tends to be more frequent, more experienced divers and have received additional training in scuba diving and mixed-gas use. Additionally, 43 percent were using dive computers (Table E.6, below).

Approximately the same percentage of DCI cases were DCS II cases in EAN divers (65.2 percent) as compared to air divers (62.7 percent).

Four individuals (two male, two female) had symptoms of DCI but continued to dive. Divers continued diving with symptoms that included pain, headache, itching, fatigue and dizziness.

The percentage of mixed-gas divers (43.5 percent) who used oxygen as first aid is similar to that of air divers (33.1 percent — Table E.7, Page 121).

Five of the eight (62.5 percent) DCS I cases called for assistance within 12 hours but one diver waited up to an additional 12 hours to report for recompression. Two (25 percent) more of the DCS I cases waited four days to call for assistance and receive treatment.

Table E.6 *Conventional Disease Categories*

Final Diagnosis	Frequency	1996 Percent	1995 Percent
DCS I	8	34.8	12.5
DCS II	15	65.2	87.5
TOTALS	**23**	**100.0**	**100.0**

Seven of the 15 (46.7 percent) DCS II cases called for assistance within 12 hours, four more (26.7 percent) waited another twelve hours to call and report for treatment. Three individuals (20.0 percent) waited two days to call for assistance and one individual (6.7 percent) waited seven days to call for assistance and receive treatment.

Overall there were nine divers (39.1 percent) who had residual symptoms. This overall incidence is similar to the 37 percent overall incidence in air divers (Graph 5.6, page 58), but a larger fraction of residuals in nitrox divers were neurological compared to air divers (35 percent versus 23 percent). The single-pain residual lasted for two months. The eight residual neurological symptoms lasted from three days to unresolved at a three-month follow-up call.

Table E.7 ***First Aid Used***

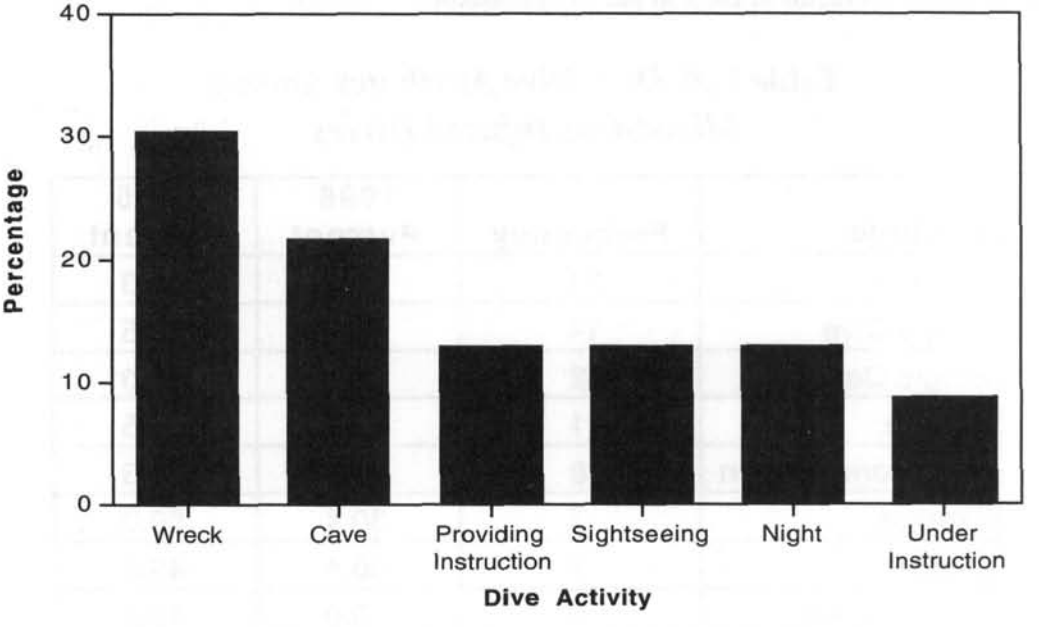
First Aid	1996 # of Divers	1995 # of Divers
Oxygen	10	7
Oral fluids	9	12
Aspirin	6	8
Position	1	3
TOTAL	**23**	**16**

Dive Profile Information

The activity of mixed-gas diving appears to be linked to more specialized dive activities, compared to that of recreational air divers (Graph E.1, below). Wreck and cave divers were among the first scuba divers to utilize mixed gases for recreational scuba.

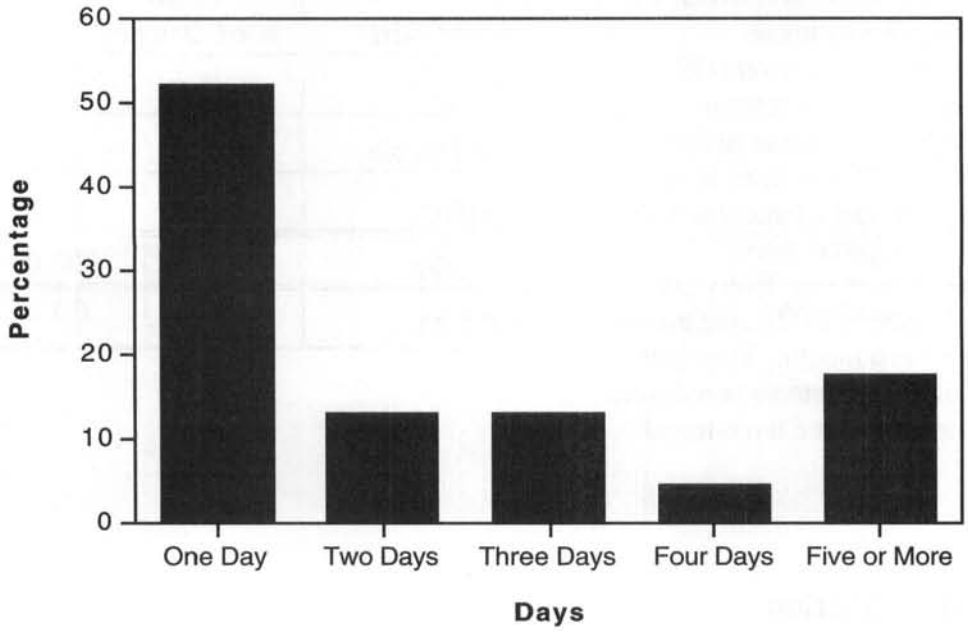
It is not surprising to find these activities are more popular in this limited population.

Graph E.1 ***Primary Dive Activity***



Twelve out of 23 divers (52.1 percent) were injured on the first day of diving (Graph E.2, below). The same trend is found in air divers, where 48 percent of injuries occur on the first day of diving. Mixed-gas divers tend to be more active divers, with 82.6 percent having dived in the 30 days preceding their injury. This compares to 52.8 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 / 24 meters or greater, making square, single dives. The low number of divers doing no-stop dives suggests longer, deeper, task-oriented dives. This takes advantage of the longer no-decompression bottom times by using a lower partial pressure of nitrogen. No rapid ascents were reported as a factor in DCS in the 1996 database.

Table E.8 ***DCS Dive Attributes Among Mixed-Gas Injured Divers***

Attribute	Frequency	1996 Percent	1995 Percent
≥ 80 fsw	21	91.3	81.3
Single Dive	14	60.9	62.5
Single Day	12	52.2	50.0
Square	11	47.8	62.5
No decompression	8	34.8	31.3
Exertion	7	30.4	50.0
Current	7	30.4	43.8
Rapid ascent	0	0.0	12.5

Ten of 23 mixed-gas divers (43.5 percent) were using a computer to help calculate their dive (Table E.9, below), similar to the 55 percent of air divers that were using a dive computer. The similarities in computer and table users were the depth of the dive and decompression diving.

Among the 23 mixed-gas divers, no one mentioned having an equipment problem. This probably reflects the higher level of training, preparedness and familiarity with equipment in this population.

Table E.9 ***Attributes of Computer and Table Divers***

	Computer Divers		Table Divers	
Attribute	**Frequency**	**Percent**	**Frequency**	**Percent**
Repeat Dive	9	90.0	5	38.5
≥ 80 fsw	8	80.0	13	100.0
Decompression	6	60.0	9	69.2
Multi Day	6	60.0	5	38.5
Multilevel	6	60.0	7	53.8
Exertion	4	40.0	3	23.1
Single Day	4	40.0	8	61.5

Summary

Like computer-assisted diving, EAN 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 appears to be practical for only a small group of divers because it has a high-profile "technical" appearance, which may not be consistent with the general public's view of recreational scuba diving.

The injuries reported among EAN and mixed-gas divers are not unlike those injuries reported in air divers. The fraction of injuries reported as DCS II and the number of residual symptoms are similar in the two groups. The main distinction, however, is that a higher fraction of residuals in EAN divers were neurological compared to air divers.

It appears that over half of the injured EAN or mixed-gas divers were using these gases to extend their bottom times. In the 23 cases, a total of 37 dive profiles were conducted; eight divers made seven no-decompression dives (45.9 percent), while 15 divers made 20 dives, all of which were decompression dives with extended bottom times (54.1 percent). 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 EAN and mixed-gas diving 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-miss and fatal diving incidents.

The decision to use EAN or mixed gas in a reasonably safe manner must include proper training and certification through one of the many training associations. It must also include the acknowledgment that mixed-gas diving has additional risks, and greater caution must be extended to improve these risks.

Appendix F
Diving Definitions

Arterial Gas Embolism — Also referred 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 ascent 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 a syndrome caused by bubbles of inert gas forming in the tissues and bloodstream as a result of scuba diving. DCS is manifested in two major forms, DCS I and DCS II.

DCS I — decompression sickness typified by muscle and joint pain, fatigue and/or skin symptoms (itching, rash).

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 45) 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.

< Two Years' Experience — The diver had been diving for less than 24 months on the day of interest.

Mixed Gas — Any breathing medium containing a percentage of oxygen and nitrogen which differs from compressed air. 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 / 18 meters and stays for 10 minutes then descends to 80 feet / 24 meters and stays for five minutes, ascends to 50 feet / 15 meters for 10 minutes and then to 20 feet / 6 meters 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 / 18 meters per minute. A rapid ascent occurs when a diver ascends faster than recommended. Rapid ascents are often uncontrolled and can be caused by overinflation, poor buoyancy control, being underweighted or panic.

Repeat Dive / Repetitive 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 / 18 meters and stays at 60 feet for 30 minutes before ascending). Square and multilevel dives are mutually exclusive.

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

- Diving deeper than 130 feet / 40 meters;
- Using a breathing mixture other than compressed air;
- Decompression or overhead diving (diving in shipwrecks or caves);
- Special training and equipment were used.

Within Limits — represents divers who were diving within their computer or table limits.

Appendix G

Abstracts — 1996-97

Caruso JL, Uguccioni DM, Dovenbarger JA, Bennett PB. Fatalities Related to Cardiovascular Disease in the Recreational Diving Population. Undersea and Hyperbaric Medicine 24(Suppl); A102: 26, 1997.

Caruso JL, Oury TD, Crapo JD, Marklund SL, Carlsson LM, Piantadosi CA. Extracellular Superoxide Dismutase Mice are More Sensitive to Central Nervous System Oxygen Toxicity. Undersea and Hyperbaric Medicine 24(Suppl); A8: 26, 1997.

Caruso JL, Uguccioni DM, Mebane GY, Dovenbarger JA. Recreational Diving Fatalities in the U.S., 1990-1994: Patterns and Trends. Undersea and Hyperbaric Medicine 23(Suppl); A90: 60, 1996.

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Dear G de L, Vann RD, Pieper CF, Bute BP, Uguccioni DM, Thalmann ED. DCI Symptoms Do Not Appear to Form Syndromes. Undersea and Hyperbaric Medicine 24(Suppl); A144: 33, 1997.

Doyle K, Baek PS, de Long ER, Uguccioni DM, Dear G de L, Stolp BW, Dovenbarger JA, Moon RE. Menstruation as a Risk Factor for Decompression Illness (DCI) in Female Scuba Divers Taking Oral Contraceptives (OC). Undersea and Hyperbaric Medicine 24 (Suppl); A143: 33, 1997.

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Lawler W, Hargasser S, Moon RE, Uguccioni DM, Stolp BW. Two-year Follow-up of Decompression Illness (DCI). Undersea and Hyperbaric Medicine 23(Suppl); A47: 35, 1996.

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Uguccioni DM, Dovenbarger JA, Corson K, Ramsey B. Australian/New Zealand Diving Accident Database 1992-1997. Hyperbaric Technician and Nurses Association Conference; Sydney Australia, 1997.

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Vann RD, Dear GdeL, Pieper CF, Bute BP, Uguccioni DM, Thalmann ED. Correlation of DCI Signs and Symptoms with Classical Diagnosis. Undersea and Hyperbaric Medicine 24(Suppl); A145: 33, 1997.

Vann RD, Bute BP, Uguccioni DM, Smith LR. Repetitive Recompression in DCI Therapy. Undersea and Hyperbaric Medicine 23(Suppl); A45: 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. Undersea and Hyperbaric Medicine 23(Suppl); A49: 36, 1996.

Appendix H

Total Reported Cases by Year and Region: 1986 - 1993

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**

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***

* *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.*

Total Reported Cases by Year and Region: 1986 - 1993

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***

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.*