Report on Decompression Illness and Diving Fatalities

DAN's Annual Review of
Recreational Scuba Diving
Injuries and Deaths
Based on 1998 Data

2000 EDITION

US $25

Report on Decompression Illness and Diving Fatalities

DAN's Annual Review of Recreational Scuba Diving Injuries and Fatalities Based on 1998 Data

2000 Edition

by

DAN

Divers Alert Network

Divers Alert Network

Divers Alert Network's "Report on Decompression Illness and Diving Fatalities" presents self-reported, retrospective data from hyperbaric treatment facilities.

The Divers Alert Network "Report on Decompression Illness and Diving Fatalities: 2000 Edition" presents self-reported, retrospective data on 431 cases of decompression illness (DCI) and 83 diving-related fatalities that occurred during calendar year 1998 (January 1 - December 31, 1998). The 2000 Edition of the Report also includes reviews of 4,889 DCI cases for the 11 years from 1987-1997 and of 828 fatalities for the nine years from 1989-1997. The 2000 Report introduces Project Dive Exploration, a prospective field study of recreational diving that used dive computers to collect 12,849 dive profiles.

The 1987-1997 DCI data were acquired with the Diving Accident Report Form (DARF). In 1998, DAN revised the DARF in an effort to describe DCI symptoms and cases more completely and accurately. The revised form, called the Diving Injury Report Form (DIRF), was used to collect the 1998 data. Copies of the DIRF and dive incident reports are available through DAN's Research Department at 1-800-446-2671, 1-919-684-2948, or on DAN's website at www.DiversAlertNetwork.org.

The Diving Accident Report Form (DARF) on which the 1987-1997 data were based included three diagnostic categories for describing the injuries that can occur after ascent from diving or to altitude. These categories were: Arterial Gas Embolism (AGE), Type I Decompression Sickness (DCS-I), and Type II Decompression Sickness (DCS-II).

Arterial Gas Embolism results from pulmonary barotrauma that allows gas bubbles to enter the arterial circulation. AGE symptoms are usually referable to the brain. Decompression sickness occurs when bubbles form in blood and tissue. DCS can affect practically any body system. If AGE occurs during a dive after body tissues (particularly the brain) have absorbed significant nitrogen, injury can be particularly severe. This circumstance has sometimes been referred to as Type III DCS.

The traditional diagnostic categories DCS-I, DCS-II, and AGE have definitions that are widely although not universally agreed upon:

- DCS-I involves only itching, rash, joint or muscle pain, swelling, or fatigue. No other symptoms may be present for a diagnosis of DCS-I.

- DCS-II involves neurological symptoms including muscle weakness, paresthesia (tingling or numbness), abnormal bladder or bowel function, sensory disorders (vision, hearing), memory problems, and personality changes. DCS-II also includes cardiopulmonary signs/symptoms and death. A diagnosis of DCS-II may include DCS-I symptoms.

- AGE involves the rapid onset (<10 min) of cerebral symptoms. Diagnosis of AGE is supported by evidence of pulmonary barotrauma, short dives, rapid ascent, and rapid symptom onset. A diagnosis of AGE may include DCS-I and DCS-II symptoms.

DCS has numerous signs and symptoms, many of which can be indistinguishable from AGE and also from non-diving illnesses. Because there are no conclusive tests for AGE and DCS, all diagnoses begin with the question, "Was the patient exposed to a decrease in pressure?" Diagnoses of DCS or AGE are presumptive and frequently ambiguous in mild cases. Moreover, divers often overlook, ignore, or deny their symptoms.

These difficulties prompted Drs. James Francis and David Smith to propose the inclusive term "decompression illness" (DCI) for all injuries due to bubbles that arise from reduced barometric pressure (see Describing Decompression Illness. 42nd UHMS Workshop, Francis and Smith, eds., UHMS 79(DECO)5/15/91, May 1991). This does not mean that AGE and DCS do not exist. AGE predominates during submarine escape, for example, and DCS predominates during exposure to high altitude. The descriptive DCI classifications are more objective, however, and offer data that are better suited to the study of severity and outcome as no mechanistic assumptions are involved. The DCI classifications were adopted for the Diving Injury Report Form (DIRF). A summary diagnosis in the DIRF included the choice of DCI or the traditional diagnoses for people unfamiliar with the new terminology.

DCS has numerous signs and symptoms, many of which can be indistinguishable from AGE and also from non-diving illnesses.

The primary goal of DAN's "Report on Decompression Illness and Diving Fatalities" is to understand the contributing factors of diving injuries and fatalities.

One hundred years ago, fatalities and serious diving injuries were common. Today they are rare and often seem to be associated with unsafe behaviors or hazardous conditions, but they also occur without apparent cause. Understanding the contributing factors could lead to safer diving. The primary goal of DAN's annual "Report on Decompression Illness and Diving Fatalities" is to further this understanding. The 2000 Edition presents raw data without interpretation. This is groundwork for case control studies to compare diving fatalities and injuries with Project Dive Exploration dives in which injuries were rare.

As with most DAN programs, the majority of the funding for this report derives from annual DAN membership dues. DAN also wishes to recognize the many DAN Sponsor dive clubs, stores, resorts, instructors, corporations, and friends of DAN who support Divers Alert Network and dive safety.

Cover photo by DAN member Julie S. Barber, 1999 Our World-Underwater Scholar.
Layout and Cover design by Rick Melvin.

Acknowledgments

Data for the 2000 "Report on Decompression Illness and Diving Fatalities" have been collected and assembled by DAN employees and associated staff. DAN wishes to recognize the following people and departments for their important contributions:

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DAN wishes to thank all of the individuals involved in the worldwide diving safety network. This network includes many hyperbaric physicians, DAN on-call staff, nurses and technicians from the national network of chambers who fill out DAN reporting forms. DAN also wishes to thank the local sheriff, police, emergency medical personnel, U.S. Coast Guard, medical examiners and coroners who submitted information on scuba fatalities.

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David Vote, M.D.
Charles Gleaton, M.D.
David Hendricks, M.D. .

Project Dive Exploration Dive Profile Collection (collectors and number of dives)

DATA COLLECTION CENTERS	
Nekton Pilot	3737
Paradise Divers	1166
Kathy Coulombe/ Discovery Diving	950
Dutch Springs	454
Diveshop II	345
DAN STAFF	
Randy Sitzes	1425
Donna Uguccioni	575
Peter Winkler	344
Daniel Nord	181
Petar Denoble	128
INDEPENDENT FRCS	
Sue Davidson	1246
Daniel Millikovsky	192
Terry Loar	179
William Charlton, Jr.	166
Terry Laraman	154
Scott Winners	131
John LaPere	113
Larry Hill	103
Denis Burlage	101
Michael Rainone	85
Edrianna Stilwell	84
Lloyd Garrard	76
Kelly Rockwood	68
Peter Goldberg	63
Robert Lapinski	60
Eileen Weinstein	41
John Scruggs	35
Martin Naaktgeboren	34
Robert Hildebrand	32
Peter Mueller	24
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Amy Juried	19
Robert Schlosser	17
John Sloan	13
Philip Weber	12
Michael Johnson	5
Catherine Rehm	4
Christopher Owen	4
Daniel Moore	2

DAN Regions and Regional Coordinators for Hyperbaric Treatment

Divers Alert Network uses a network of 270 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 and Tennessee
Peter Bennett, Ph.D., D.Sc. and Richard Moon, M.D.
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Southwest Region – Arizona, California, Nevada and Utah
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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
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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
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Midwest Region – Illinois, Indiana, Iowa, Kentucky, Michigan, Minnesota, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin and Wyoming
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Northwest Region – Alaska, Idaho, Montana, Oregon and Washington
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Pacific Region – Guam, Hawaii and U.S. Territories
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Florida and Caribbean Region – Florida and Caribbean Basin
Harry Heinitsh, M.D. and Marc R. Kaiser
Diving Medical Center at Mercy Hospital, 3663 South Miami Avenue, Miami, FL 33133

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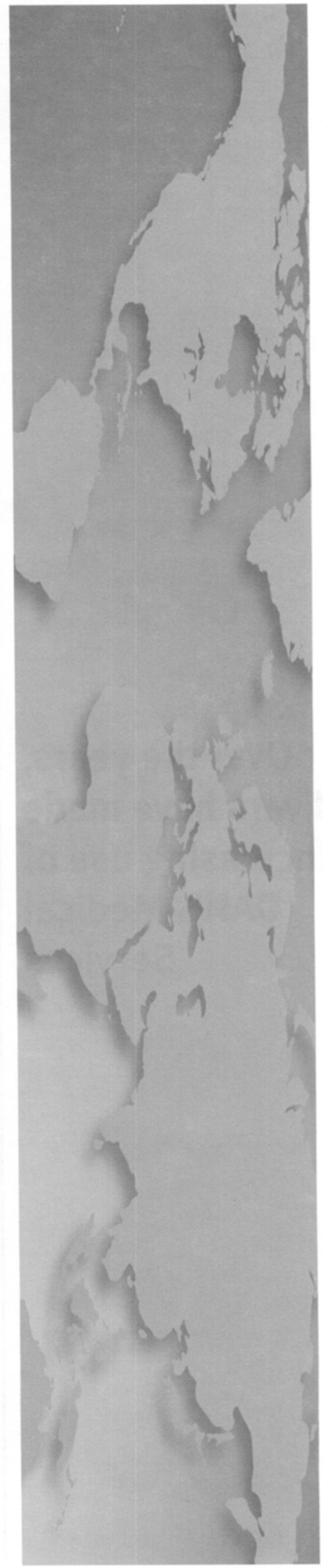


To report an injury, a fatality or a near-miss in diving, call DAN's Medical Department at +1-919-684-2948 or 800-446 2671.

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

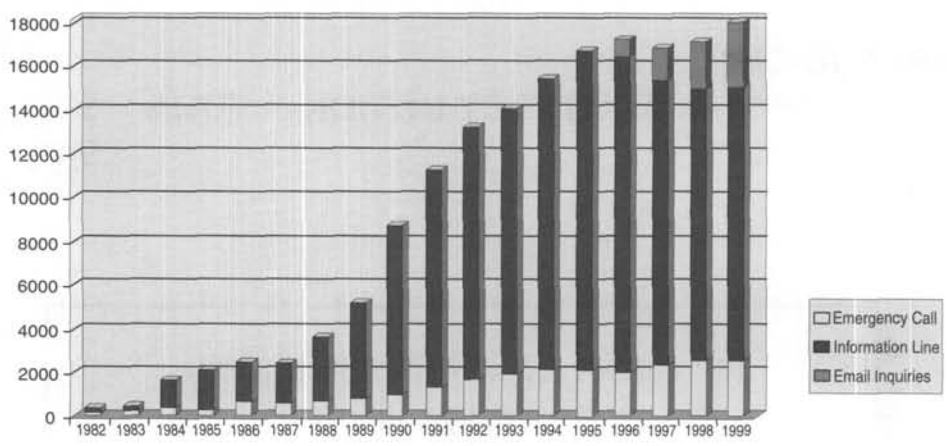
DAN - '*Your* Dive Safety Association'

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

DAN was founded in 1980 to provide an emergency hotline to serve injured recreational divers and the medical personnel who care for them. Originally funded by government grants, DAN today 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

Over the years, divers have made increasing use of DAN's Medical Services



DAN is best known for its 24-Hour Diving Emergency Hotline, the 9-to-5 Dive Safety and Medical Information Line and its dive-related medical research programs. DAN America and its affiliates in Europe, Japan, Southeast Asia-Pacific 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 about scuba safety and health.

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 1998 DAN answered more than 2,200 calls for emergency assistance from its members and divers.

DAN's Medical Information Line at +1-919-684-2948 (or 1-800-446-2671 in the United States and Canada) is available weekdays from 9 a.m. to 5 p.m. Eastern Time (1400-2200 Greenwich Mean Time).

Also, divers may visit the medical pages of the DAN website — www.DiversAlertNetwork.org — where they can find answers to general questions on diving fitness and health. For a more detailed response, callers may make non-emergency medical inquiries of a more specific nature.

When divers have questions about their health in relation to diving, if they need to find a dive physician in their area, or if they have questions on medicines and diving, diving after surgery or other dive-related issues, DAN's medical information specialists are there to help. The Medical Information Line and DAN's website allow divers to talk to a specially trained diving medical technician about non-emergency diving safety and health concerns. Respondents include DAN medics with the resources of DAN's senior medical staff, on-call physicians, diving researchers at DUMC's Center for Hyperbaric Medicine and Environmental Physiology and other experts in dive medicine.

In some cases, DAN may refer callers to a diving medical specialist in their region for further evaluation. In 1998, DAN's Medical Department received 14,494 information calls (including 2,255 emails). Since its beginnings in 1980, DAN has helped more than 158,404 callers through these telephone services.

Medical information specialists and DAN physicians offer emergency consultation and referral services to injured divers worldwide.

DAN Dive Health and Safety Research

DAN's Research Department is dedicated to the study of diving health issues. Prospective experimental research, such as the Ascent Rate Study, is conducted in the pressure chambers of the Center for Hyperbaric Medicine and Environmental Physiology at Duke University Medical Center. Field research, such as Project Dive Exploration, Doppler studies and the Diving with Diabetes projects, is conducted at diving locations all over the world.

The research conducted by DAN requires the use of specialized hypo-hyperbaric scientists and physicians, software development and technical staffing. DAN projects are privately funded through DAN membership and dive industry support.

Diabetes and Diving Project

In 1996, DAN Research began a project to determine the relative safety of people diving with insulin-requiring diabetes. Approved by DUMC's institutional review board, this project was launched in 1997. As of December 1999, 423 dives had been collected from 33 divers with insulin-requiring diabetes.

Supporters of the project include: the Aggressor Fleet, Inc.; Nekton Cruises Inc.; the Underwater Explorers Society (UNEXSO) in the Bahamas; and these DAN Sponsors in Cozumel, Mexico: AquaWorld, Albatros Charters, Blue Bubble Divers, Caribbean Divers, Casa del Mar, Cozumel Equalizer SA, Del-Mar Aquatics, Dive Paradise, Mako Tours, Scuba Club Cozumel, Sand Dollar, Cha Cha Cha Divers, Scuba Du.

Bayer Corporation and Can Am Care have also supported this project with equipment and supplies. The study is testing guidelines for blood glucose monitoring and collecting data on blood glucose levels before and after diving. Data collection will be completed in 2000, with researchers presenting data at the Undersea and Hyperbaric Medical Society (UHMS) Annual Scientific Meeting.

Project Dive Exploration will help provide insight into the behavior, dive profiles and characteristics of recreational divers associated with decompression illness.

Project Dive Exploration

Project Dive Exploration uses recording dive computers to collect information on dive profiles. As of December 1999, PDE had collected 14,000. PDE goals are to create a database of both safe dives and dives that result in injuries. This will help provide insight into the behavior, dive profiles and characteristics of recreational divers associated with decompression illness (DCI). Dive computer manufacturers Cochran, Suunto, and Scubapro/Uwatec have strongly supported this project. Volunteer Field Research Coordinators (FRC) and Data Collection Centers(DCC) also are integral to collection of dive data. For a list of FRCs and DCCs, see Page 5.

Flying After Diving Study

One of DAN's most ambitious research programs, a study of flying after diving, was completed in December 1998. Conducted jointly by DAN and the Center for Hyperbaric Medicine and Environmental Physiology, the experiment exposed volunteer divers to various dive profiles and a subsequent flight at the maximum commercial airline cabin altitude of 8,000 feet (2,438 meters). The goal was to develop guidelines for recreational divers for safe intervals between diving and flying aboard a commercial airliner. Researchers are scheduled to present data from this project at DEMA 2000 in January and will also submit results for publication later in the year 2000.

Aging Diver Study

Begun in 1999, DAN's Aging Diver Study uses the methodology of (PDE) and seeks certified divers who are 50 or older. Of particular interest is the occurrence of equipment problems, diving medical problems, non-diving medical problems and other diving-related incidents. In addition to the methods of PDE, this study includes an additional medical history form plus a dive lifestyle survey.

DAN's Doppler Field Studies

Ongoing for the past 10 years, DAN Doppler studies also incorporated the methodology of PDE during Phase III. Conducted on liveaboard dive boats in the Caribbean and in the Pacific, 281 repetitive, multiday dive profiles were collected and analyzed. This work seeks to estimate the relationship of Doppler-detected bubbles to the dive profile. The final Doppler trip was conducted in 1999. That year DAN also submitted a manuscript on open-water Doppler monitoring to the Journal of Undersea and Hyperbaric Medicine. Additional information is scheduled for publication in *Alert Diver*, DAN's member publication, later this calendar year.

Supporters of the Doppler Field Study include Aggressor Fleet, Peter Hughes Diving Inc., Mike Ball, Nekton Cruises, Caribbean Explorer Ventures, Borneo Divers, Tharfinn and Caribbean Marine Research Center.

DAN's Aging Diver Study uses the methodology of Project Dive Exploration (PDE) and seeks certified divers who are 50 or older.

U.S. Navy and DAN Survey Recreational Divers

In 1998, DAN worked with the U.S. Navy to help them understand the diving practices of recreational divers. This includes information regarding demographics, experience and diving habits.

The Navy has 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 set out to find sonar levels that would not cause problems in the recreational community and conducted studies involving non-military-trained sport divers. The Navy's aim was to determine how representative these subjects are of the sport diver population: its link to DAN came in the form of DAN's development and implementation of a survey form sent to recreational divers.

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

DAN sent out 3,000 surveys and received completed replies from 1,654. During 1999, DAN and Navy researchers presented data at the annual Undersea Hyperbaric Medicine Society (UHMS) scientific meeting. DAN continues to work with the Navy to determine where recreational divers are conducting their dives.

Other Projects

The goal of DAN's Ascent Rate Study is to determine an appropriate rate of ascent for recreational divers.

Other major projects with which DAN personnel are involved take place at the Center for Environmental Physiology and Hyperbaric Medicine. One of these projects is DAN's Ascent Rate Study, which began in 1999. Its goal is to determine if differences exist in the incidences of decompression sickness and venous gas embolism between 10 and 60 foot-per-minute ascents after dives to 100 feet/30 meters.

Another project is a NASA-funded study to determine how exercise and microgravity affect decompression illness in astronauts during "space walks," or extravehicular activity (EVA). This is in preparation for the construction of the International Space Station. Military-funded projects also study dive computers, a diving database, and oxygen-enhanced breath-hold diving.

DAN's 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 properly staffed. This program complements DAN's semi-annual dive medical courses for physicians, nurses and other allied healthcare personnel to educate the international medical community on the proper care and treatment of injured divers.

In 1996, DAN 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, begun in 1991. Until DAN developed its oxygen training program and line of oxygen equipment, many injured divers did not benefit from emergency oxygen.

As of December 1999, 82,513 divers and 8,801 diving professionals have been trained under this program. DAN also distributes a line of specialized oxygen delivery systems to treat 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 purchase oxygen and emergency oxygen equipment. DAN was instrumental in influencing these decisions. Lowering the barrier to access of oxygen was another step by DAN to ensure that injured divers would have emergency oxygen available when needed.

DAN's Oxygen First Aid Program has been training divers in emergency oxygen skills since 1991.

The Oxygen First Aid for Aquatic Emergencies Program

Since the program began in 1999, more than 450 instructors/instructor trainers in the United States and abroad have received certification.

The program teaches the skills and knowledge needed to supplement Basic Life Support (BLS) and Cardiopulmonary Resuscitation (CPR) with emergency oxygen first aid. This type of emergency first aid is used following a near-drowning incident, until emergency medical services personnel arrive.

DAN Online - http://www.DiversAlertNetwork.org

DAN's website on the World Wide Web provides a wealth of information on scuba health and safety and the many benefits of DAN membership. This might include answers to frequently asked dive medical questions, oxygen course listings or the location of a DAN retail Sponsor near you. Members can order DAN products, and newcomers to DAN will be able to sign up online.

DAN Research Online
http://www.DiversAlertNetwork.org

DAN's Research Department has a website 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, DAN's "Dive and Travel Medical Guide" and dive and travel discounts.

DAN *TravelAssist* provides up to $100,000 emergency medical evacuation assistance for a DAN member or a DAN family member.

DAN members are also eligible for affordable dive accident insurance and the exclusive DAN Tag™, diving's medical emergency ID, and the DAN Dog Tag, modeled after the popular military dog tag.

As of December 1999, approximately 195,000 members support DAN in the United States, the Caribbean, Canada and Mexico, plus an additional 58,000 members of International DAN affiliates. DAN America members 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.

Alert Diver Magazine

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

DAN's 'Dive and Travel Medical Guide'

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

DAN Dive Accident Insurance

DAN members are eligible for three different levels in insurance — the Master, Plus and Standard Plans — in addition to DAN membership. DAN's Master Plan, in combination with membership benefits, offers up to $260,000 of protection for divers and travelers.

DAN pioneered dive accident insurance in 1987; and in 1992 DAN launched medical evacuation assistance member benefits. These moves helped fill a medical and financial need not being met by any other organization at the time, giving DAN members valuable additional benefits. Before these DAN programs were launched, injured divers could be saddled with large medical bills, because most health insurance would not cover some or all of the recompression and travel charges associated with a diving injury. Although this issue still exists for some divers, DAN strives to help bridge this gap through education.

DAN's Master Plan, in combination with membership benefits, offers up to $260,000 of protection for divers and travelers.

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 / 40meters	Depth Limits: 130 feet / 40meters
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*
$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	
$1,5000 accommodations**		
$1,000 airline ticket		
$2,500 lost dive equipment++		

\+ Plus the price of DAN membership ++ If the loss was a result of being injured in a dive accident

* For more detailed information on DAN insurance, please call DAN Member Services at +1-919-684-2948 or 1-800-446-2671 (U.S. & Canada) 9 a.m.- 5 p.m. Eastern Time Monday-Friday

DAN Dive Safety and Health Products

DAN members receive a special 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 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* magazine. Select products are also available on DAN's website.

DAN Tags

In 1995, DAN introduced the first medical ID tag created exclusively for divers — the DAN Tag™. Each clip-on 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 goes directly to support DAN's Diving Emergency Hotline and DAN dive research. As of December 1999, nearly 40,000 DAN tags were in use.

In December 1998, DAN introduced the DAN Dog Tag. Modeled after the popular military dog tag, the front is imprinted with DAN's familiar logo and the Diving Emergency Hotline number. The tag's midsection allows space to imprint a diver's name and DAN member number.

DAN member emergency medical evacuation assistance and dive accident insurance policy records are kept in one central secure location at DAN.

DAN 24-Hour Diving Emergency Hotline with Immediate Insurance Verification

Dive and travel medical emergencies can happen any time. Callers to DAN's 24-Hour Diving Emergency Hotline can reach experienced medical professionals who are specially trained to handle dive and travel medical emergencies at any time, day or night.

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

As of December 1999 DAN had developed plans to offer its members term life insurance coverage.

DAN Membership Discounts

DAN members are eligible for special discounts on DAN products and other services. Check *Alert Diver* magazine for the most recent offers or call DAN's Member Services Department at 1-800-446-2671.

1987-1997 Diving Injury Trends

DAN has published reports on diving injuries from 1987 to 1997. Injury trends during these 11 years are described below.

1.1 Contacts with DAN and Diving Injury Data Collection

In 1981, DAN began a 24-Hour Hotline (+1-919-684-8111) to take emergency calls from injured divers. Records of calls were kept beginning in 1986. In 1989, an Information Line (+1-919-684-2948) was added as a separate service to answer non-emergency diving medical questions, and in 1995, email service began for the same purpose. Figure 1 shows that the total contacts to DAN grew steadily from 1986-95 but leveled off and have remained relatively constant at 17,000 per year through 1998. Emergency calls have held steady at 2,000 per year since 1993.

Medics and physicians taking hotline calls arranged for recompression of injured divers at one of some 270 recompression chambers in or near the eight Regions served by DAN America. (See Page 6 section for a description of the Regions.) Reports on these and other cases were submitted annually. Missing and follow-up information was obtained by telephone.

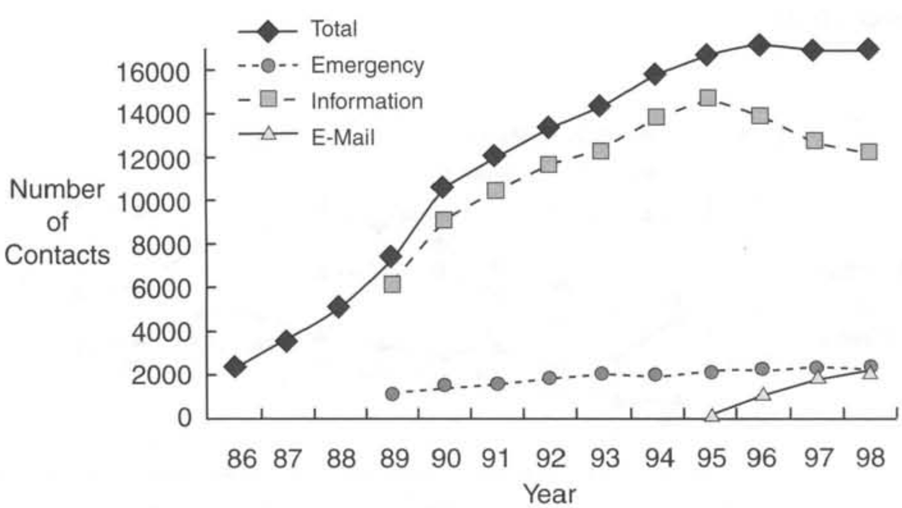


Figure 1. Contacts to DAN for medical emergencies and information.

Figure 2 is a general summary of information about DCI cases for 1987-97 received by DAN from cooperating recompression facilities. DAN may not have been informed of all cases of DCI. The upper line represents all treated DCI cases about which DAN was notified. A Diving Accident Report Form (DARF) was submitted for two-thirds of these (middle line), and cases that fit the inclusion criteria (about two-thirds) were entered into the diving injury database and later described in the annual "Report on Decompression Illness and Diving Fatalities."

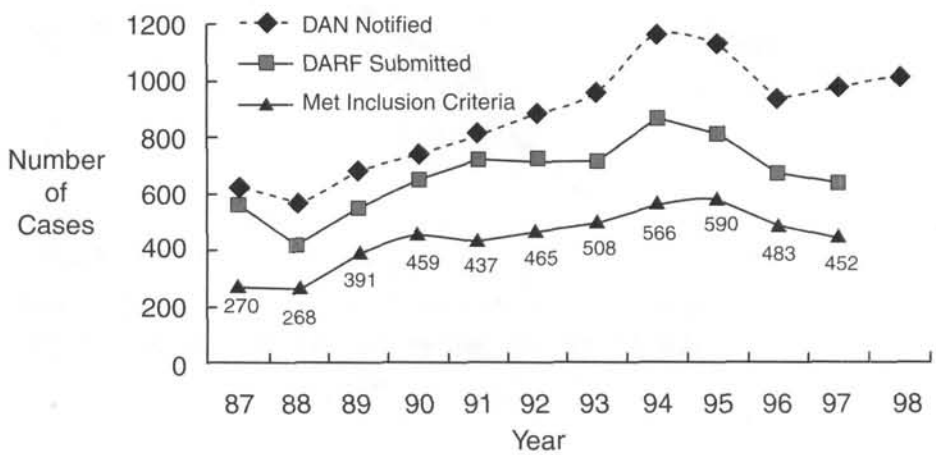
To be eligible for inclusion in the DARF database, injured divers were required to be:

- recreational divers, divemasters, or instructors diving with scuba and breathing compressed air (divers breathing other gases were placed in a separate database);
- U.S. and Canadian residents treated in U.S. chambers;
- U.S. residents treated in non-U.S. chambers;
- diagnosed as having decompression illness;
- reported to DAN by July 1 of the following year; and
- contacted by DAN after treatment.

In 1994, the number of case notifications peaked at 1,164, and the number of cases meeting the inclusion criteria peaked at 858, but notifications have remained relatively constant at about 950 from 1996-98. During the 11 year reporting period from 1987-97, 4,889 diving injuries were entered into the DARF database.

Case notifications for 1998 are included in Fig. 2, but data from 1998 are reported separately in Section 2 as the DARF was replaced by the Diving Injury Report Form (DIRF), and the inclusion criteria were changed (Section 2).

Figure 2. Cases treated, submitted, and included in the annual "Report on Decompression Illness and Diving Fatalities." Numbers by the bottom line are the cases that met the inclusion criteria for each year.



1.2 International and National Regions of Diving Injuries

Figure 3 shows that 60-70% of the diving injuries serviced by DAN America occurred in the U.S. There was a slight downward trend in U.S. injuries beginning in 1992 while injuries reported in Central America increased from 5 to 20%. The Caribbean remained relatively constant at 15%. The category "Other" includes Canada and a few injuries from the Pacific at 3-4%.

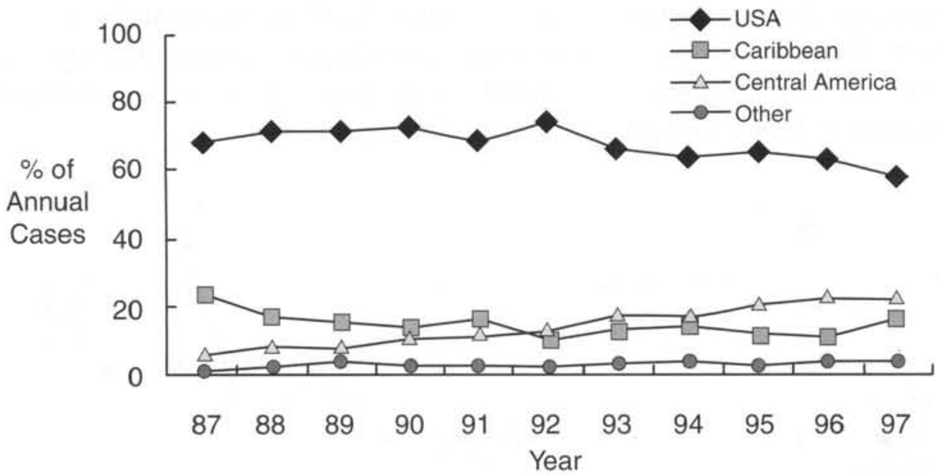


Figure 3. Geographical region in which diving injuries occurred.

Of diving injuries reported to DAN from the U.S., most occurred in Florida, California, Washington, and Hawaii (Fig. 4). Florida had about four times as many reported injuries as the other three states although there has been a downward trend in the proportion of injuries in Florida since 1990. California, Washington, and Hawaii each account for approximately 5% of total annual injuries.

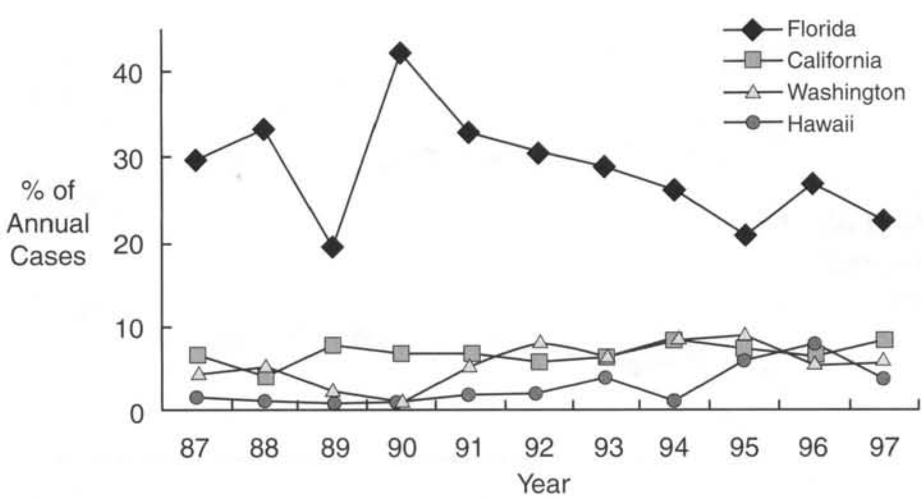


Figure 4. The most common U.S. states for diving injuries.

1.3 Characteristics of Injured Divers

Figure 5 shows that the mean age of injured divers increased from 33 to about 37 years over the 11-year reporting period. For each year, there was little difference in mean age of male and female divers treated for diving injuries. About 7% of injured divers were age 50 or older. The mean age of the youngest divers treated each year was 12.2 years (range 11-13), and no trend was evident. The mean age of the oldest divers treated was 68.7 years (range 62-77) with divers in their 60s from the first part of the reporting period and divers in their 70s from the second part. There were three to four times more injured males than females (Fig. 6). The proportion of females in the population of injured divers increased from about 22-30% during the reporting period.

Figure 5. Mean ages of male and female divers at the time of injury.

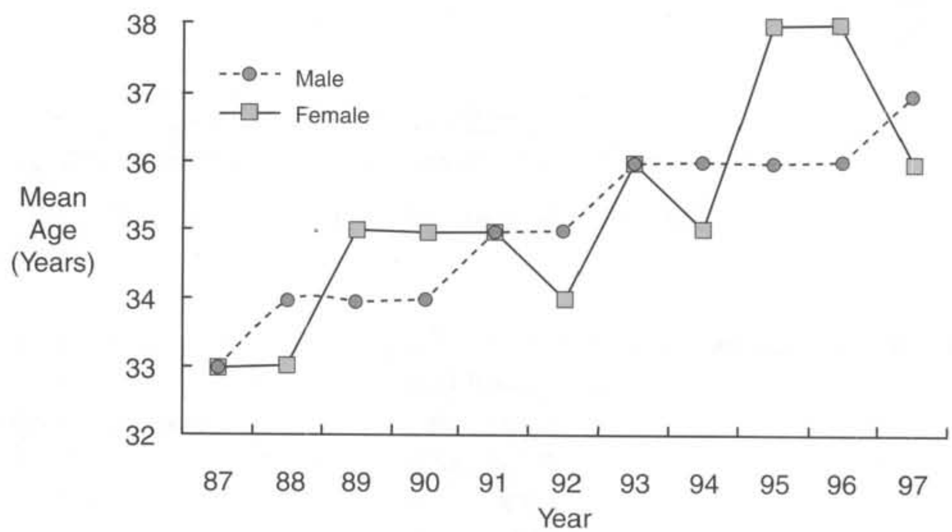


Figure 6. Relative distribution of males and females in the injured diver population.

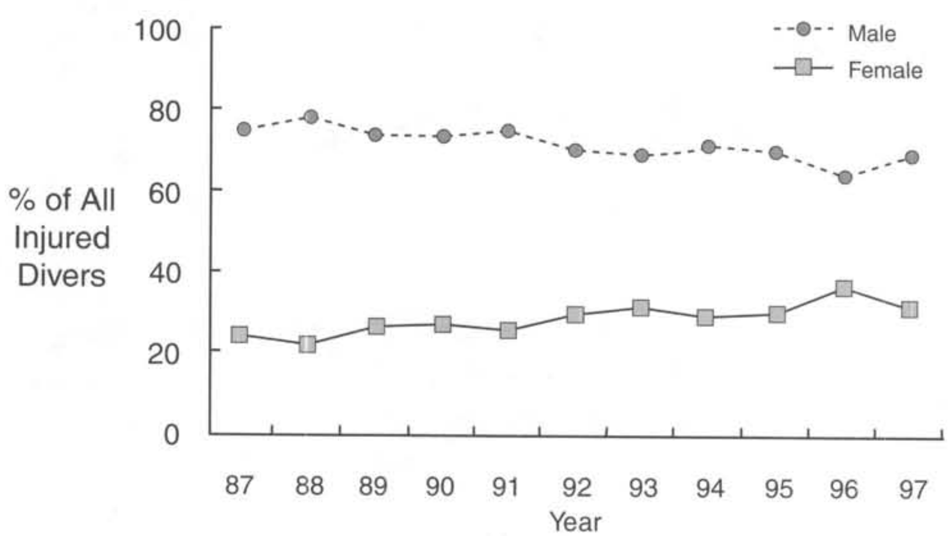


Figure 7 shows that the proportion of injured divers who were Students and Instructors remained relatively constant at about 2% and 20% of the total population, respectively, while the percentages of divers with Advanced and Basic certifications were about 30% and 50%. The proportion of Advanced Divers who were injured increased gradually while the proportion of Basic Divers decreased.

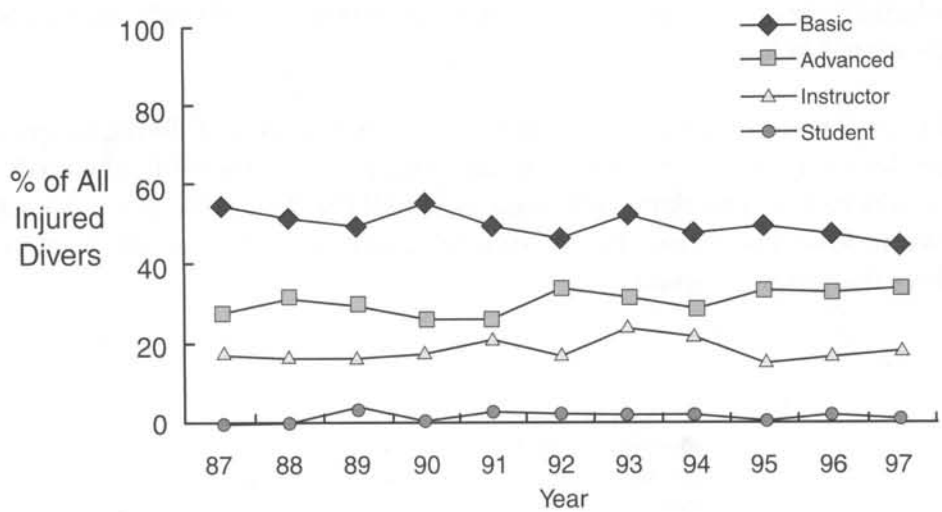


Figure 7. Certification of injured divers.

Figure 8 shows that the number of years between initial training and the dive injury fluctuated from 4-7 for females and from 6-8 for males. For the past five years, the time since initial training for injured females was only one year less than for males. Note, however, that years since initial training is not necessarily a good indicator of diving experience.

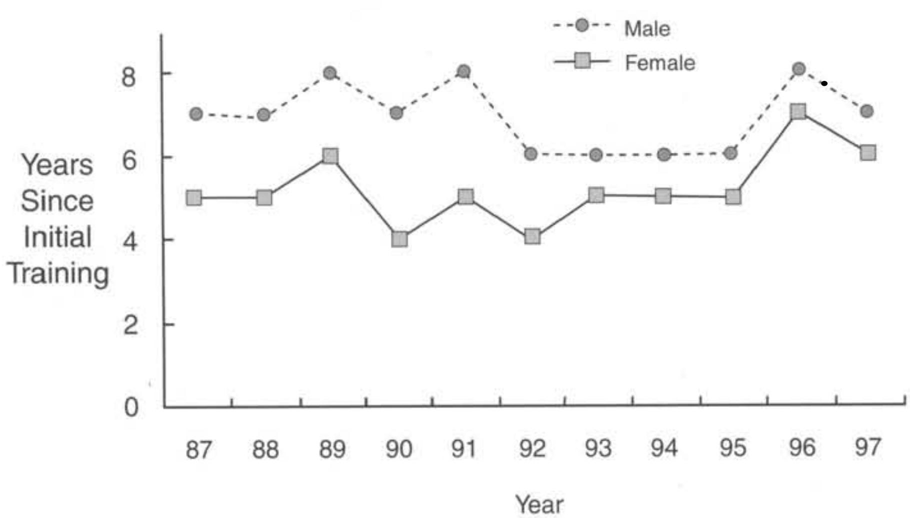


Figure 8. Years since initial training for male and female divers who were injured.

1.4 Dives by Injured Divers

Diving and altitude exposure cause injury as a result of pressure change, but divers have difficulty recalling their depth-time profiles with accuracy. Divers more readily remember certain features of the diving activity, including the number of days of diving, the number of dives, the maximum dive depth, the method of selecting the dive profiles and whether there was any post-dive altitude exposure. This information is presented below.

Figure 9 shows the mean and median number of days of diving by gender for injured divers. The mean was generally one day, while the median was two to four days, indicating that half the divers dived for at least two to four days before injury. Injured males generally had dived more days than injured females.

Figure 9. Median and mean days diving for injured males and females.

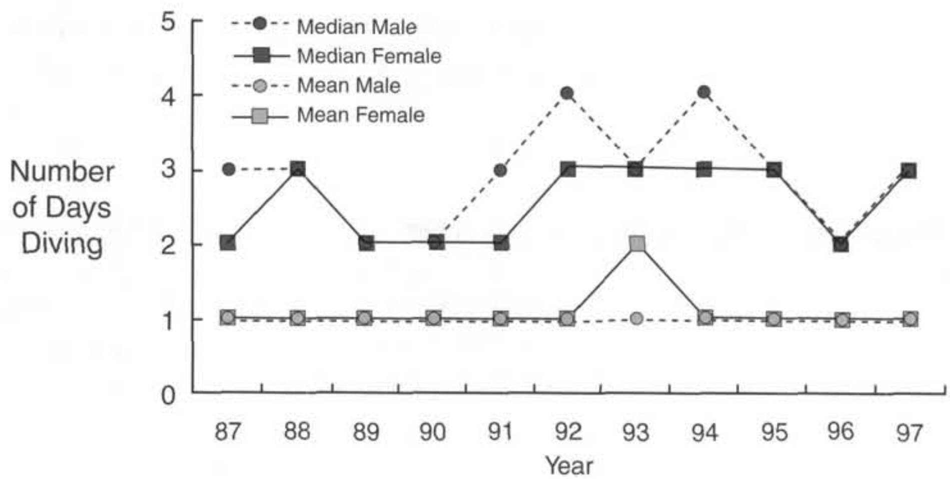


Figure 10 shows the median number of dives in the series for males and females. (The means were only slightly less, with little difference between males and females.) The median number of dives fluctuated from one to seven days over the 11-year reporting period, but diving activity before injury appears to have increased. In general, males dived one to two days longer than females before reporting injury.

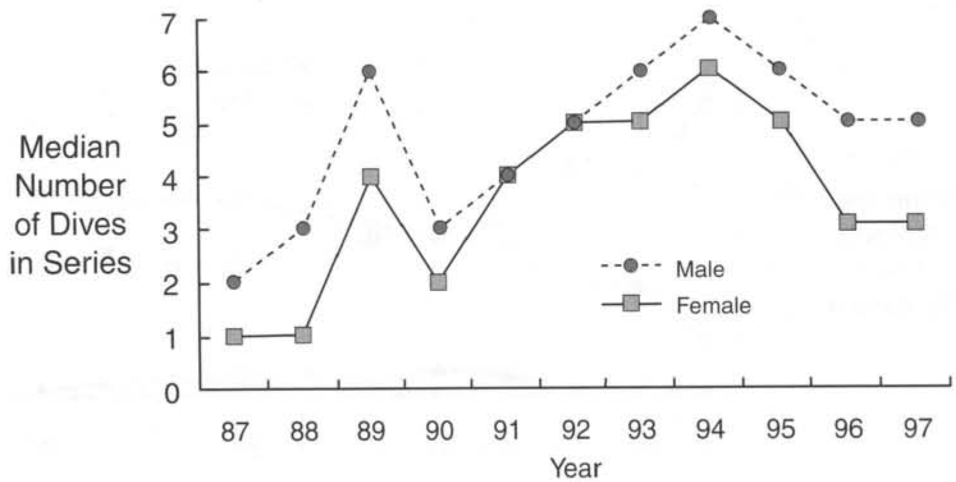


Figure 10. Median number of dives for injured males and females.

Figure 11 illustrates the mean maximum dive depth in the dive series for injured males and females. The mean maximum depth varied from 75-95 fsw (feet of sea water), with no apparent trend over the 11 years. In some years, males who were injured dived 10-20 fsw deeper than injured females, but this did not occur consistently.

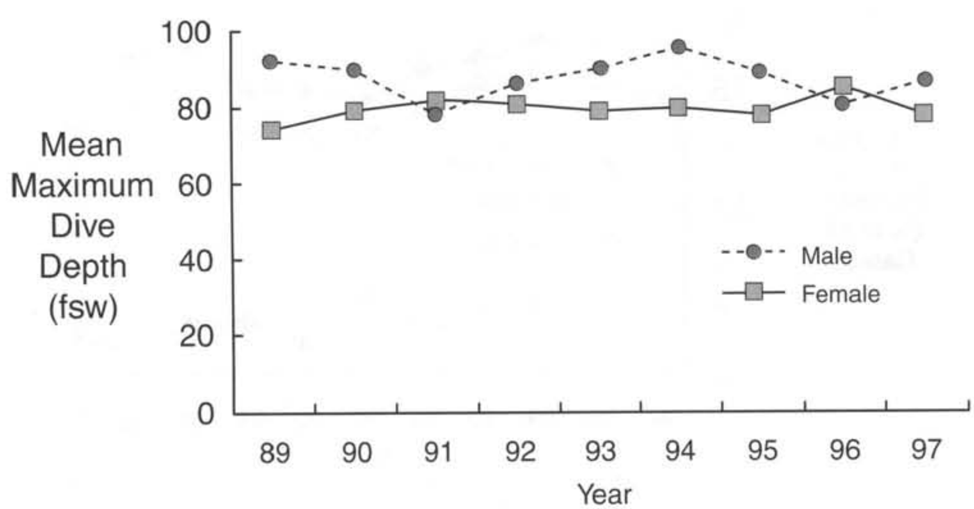


Figure 11. Maximum dive depth in series for injured males and females.

Figure 12 compares the percentage of injuries that occurred with three dive planning methods: dive computers, dive tables and following the Divemaster or Dive Guide. The percentage of divers injured while using computers increased from 15-60% over the reporting period, possibly reflecting the increasing use of dive computers. Without a measure of total diving activity, however, estimating the relative risk of injury between dive computers and dive tables is not possible.

Figure 12. Dive planning method used by injured divers.

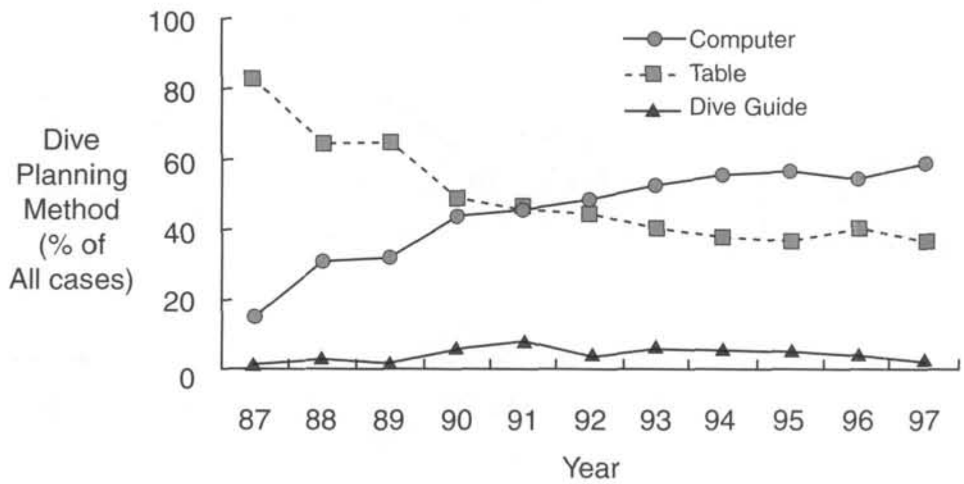


Figure 13 shows some of the procedural problems experienced by injured divers during the course of diving. At 25-30%, the most frequent problems were difficulty controlling buoyancy and making a rapid ascent. At about 5%, running out of air was also associated with injury.

Figure 13. Procedural problems experienced by injured divers during diving.

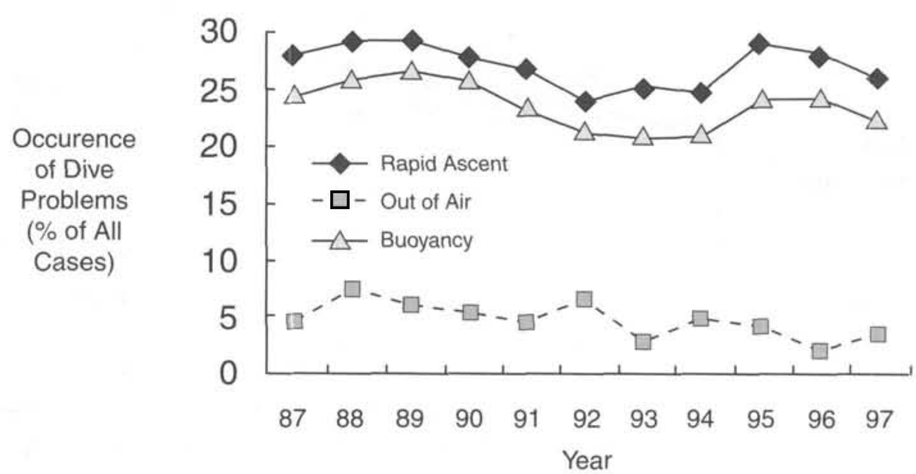


Figure 14 shows the percentages of injured divers who were exposed to altitude after diving. About 40% of all injured divers flew in pressurized or unpressurized aircraft after diving. About 15% of injured divers were evacuated by air. No strong trends are apparent.

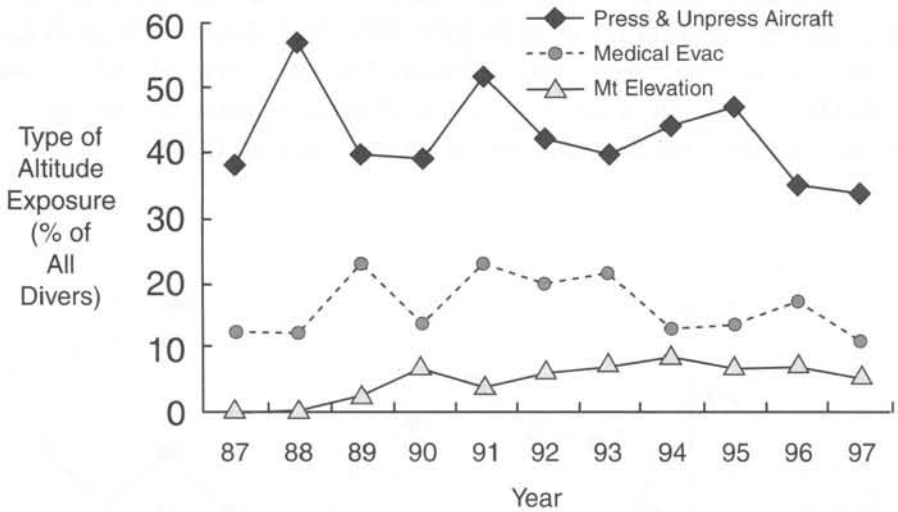


Figure 14. Injured divers who were exposed to altitude after diving.

1.5 Symptoms and Diagnoses

Figures 15 and 16 show the relative occurrence of the most common and most severe symptoms reported by injured divers (not all reported symptoms are shown). In Fig. 15, pain and numbness were present in 50-65% of all cases. In recent years, they were noted in about 60% of all cases. In Fig. 16, after initial reports in 1987 that almost 10% of all cases involved paralysis, paralysis decreased to only 3% of 1997 cases. Similarly, reports of unconsciousness decreased from 7% to 4%, and bladder dysfunction decreased from 2% to less than 0.5%.

Figure 15. Percentage of diving injury cases involving pain or numbness from diving injury cases.

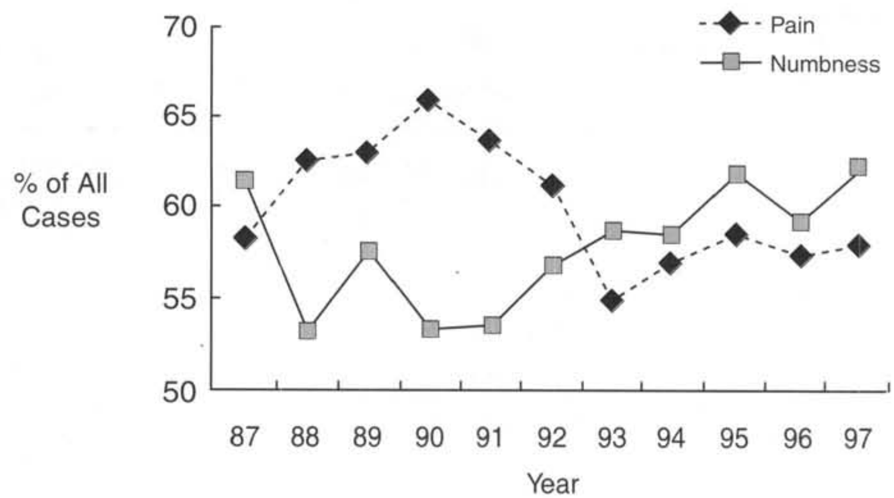


Figure 16. Percentage of diving injury cases involving unconsciousness, paralysis or bladder dysfunction.

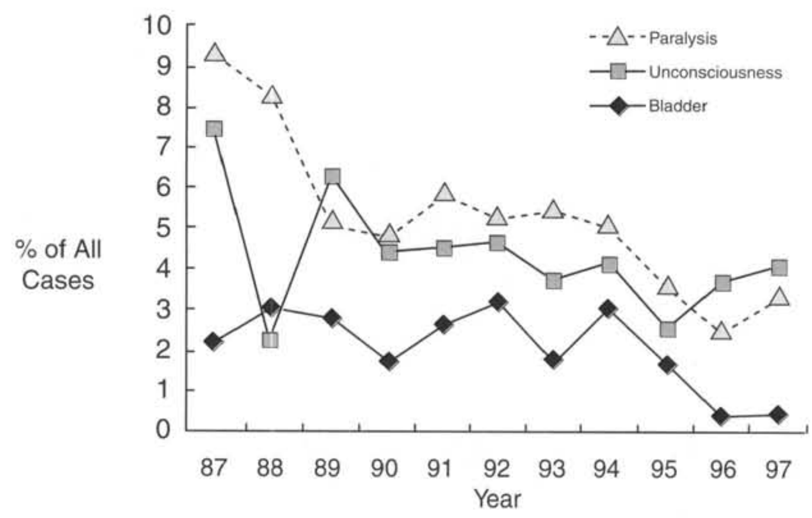


Figure 17 shows the distribution of the diagnostic classifications DCS-I, DCS-II and AGE that were assigned to diving injuries accepted into the DAN database for 1987-97. DCS-II remained relatively constant at 65-70% during the reporting period. The percentage of AGE decreased from about 20 to 10% while that of DCS-I increased from 20 to nearly 30%.

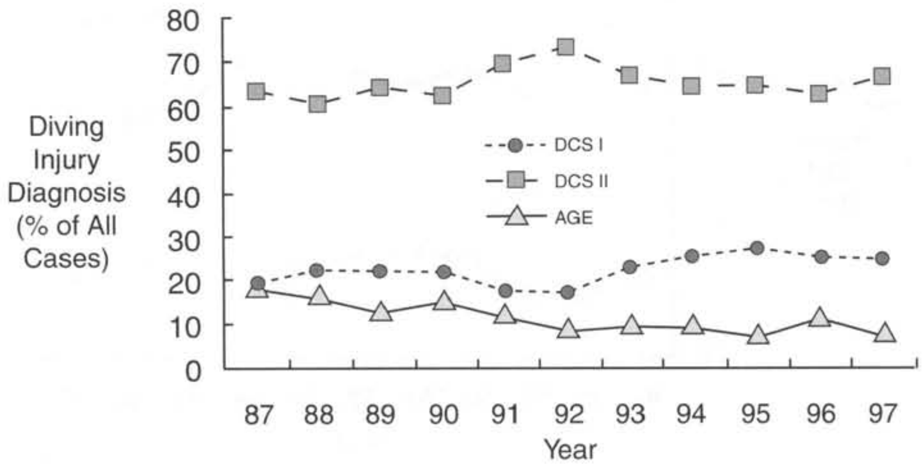


Figure 17. Classification of diving injuries in the 1987-97 data.

1.6 Therapy and Outcome

The recommended first aid for diving injuries is 100% oxygen provided at ground or sea level (normobaric) as soon as possible after the onset of symptoms. Continued oxygen first aid is recommended for as long as possible until hyperbaric therapy can begin. Figure 18 shows that the use of normobaric oxygen remained constant at 50-60% during the 11-year reporting period. The percentage of oxygen administered, and the duration for which oxygen was provided, are unknown.

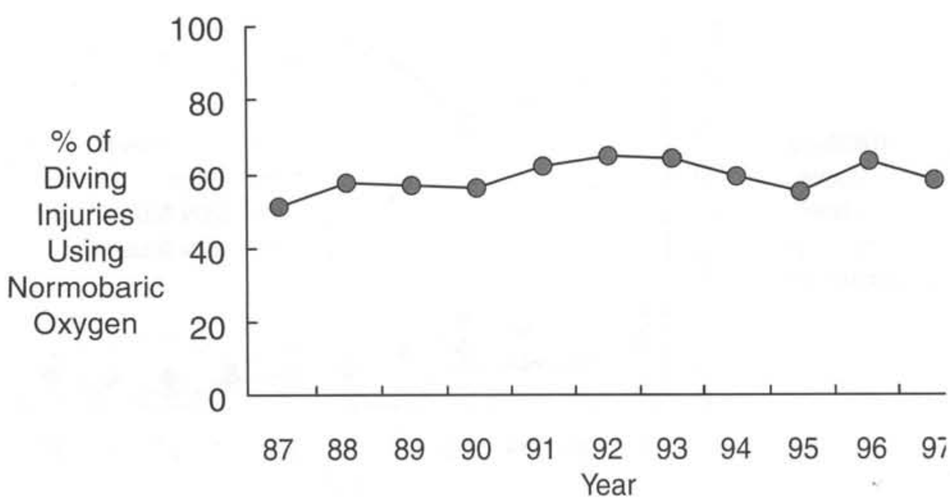


Figure 18. Use of oxygen first aid before recompression for injured divers.

Figure 19 shows that the median delay in recompression after symptom onset during the reporting period remained relatively constant at about one day. The mean delay decreased from 50 hours in 1993 to less than 40 hrs in 1997, indicating that fewer divers experienced delays longer than two days before recompression.

Figure 19. Delay in recompression after symptom onset.

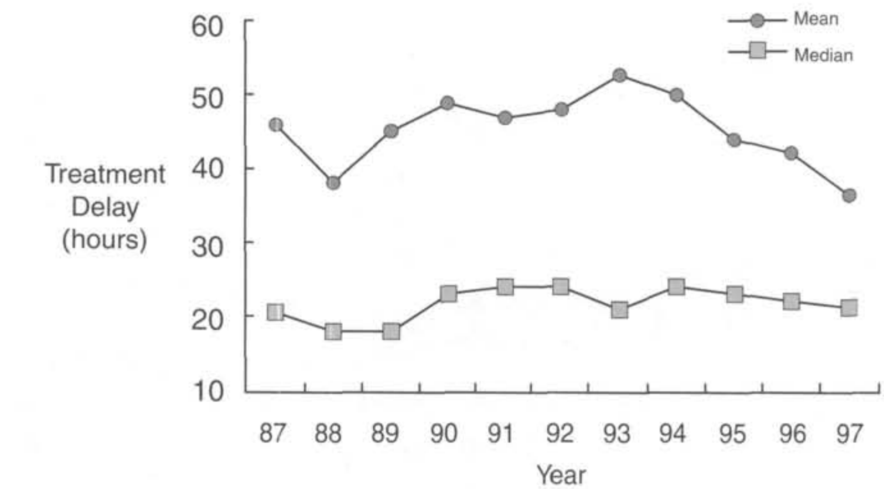
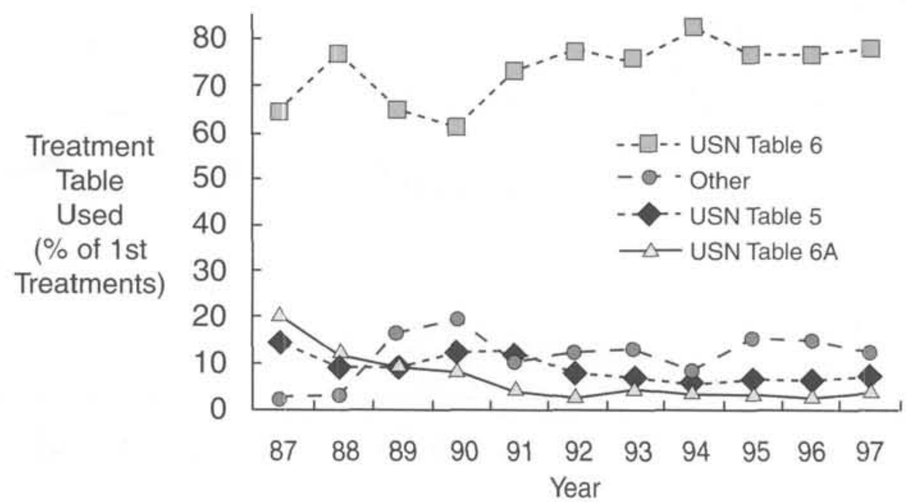


Figure 20 shows the relative use of the recompression therapy tables for the first treatment. The U.S. Navy Treatment Table 6, the most common recompression therapy, was used for the first recompression in about three-fourths of recent injuries. The use of USN Table 5 has declined from 20% to less than 5% while the use of USN Table 6A declined from 15% to 5% over the 11 year reporting period. The category "Other" includes treatment tables with depths of less than or greater than 60 fsw. These were used for initial therapy in 15% of recent cases.

Figure 20. Recompression tables used for first treatment.



The mean number of total recompression tratments decreased from three to two. (Fig. 21). The median number of treatments increased from one to two indicating that, while fewer divers were treated multiple times, more divers were treated at least twice.

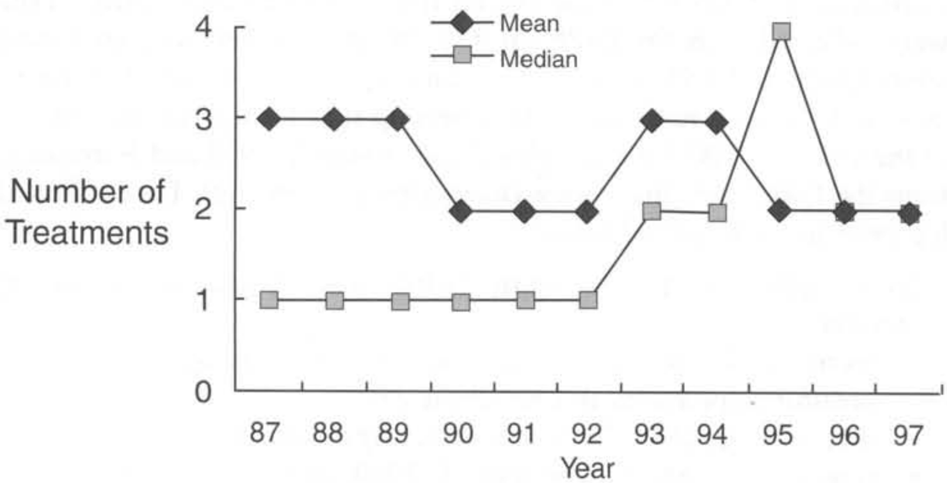


Figure 21. Number of recompression treatments of injured divers.

Figure 22 shows the relative proportions of injured divers who achieved complete, partial/temporary, or no relief after all recompression therapy. The percentage of divers with complete relief increased from 50% to nearly 70% while those with only partial or temporary relief decreased correspondingly to nearly 30%. Only a small percentage of divers reported no relief.

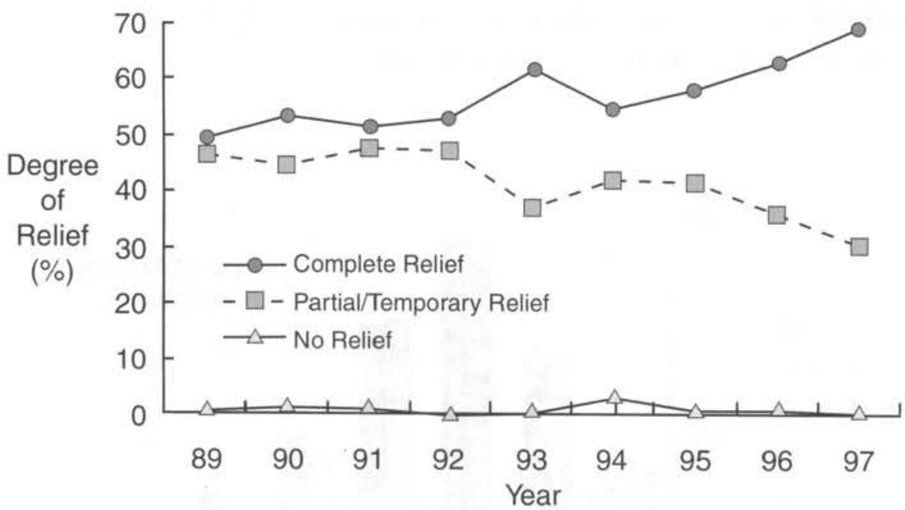


Figure 22. Relief of symptoms after all recompression treatments.

1998 Diving Injuries

To provide information that could not be obtained with the Diving Accident Report Form (DARF), DAN introduced a new data collection instrument in 1998 called the Diving Injury Report Form (DIRF). Data were collected with the DIRF on 431 divers who were injured during 1998. Of these, 54.5% were DAN members, 40.6% were not DAN members, and 4.9% did not indicate membership status. An electronic version of the DIRF (e-DIRF) was developed and tested in 1999 and is available from the DAN Web Site (www.DiversAlertNetwork.org). Data collected for 1998 are summarized below.

To be eligible for inclusion in the DIRF database, injured divers were required to be:

- recreational, occupational, or scientific divers using any breathing apparatus and breathing gas;
- divers of all nationalities treated at any chamber;
- reported to DAN by September 1, 1999; and
- contacted by DAN after treatment.

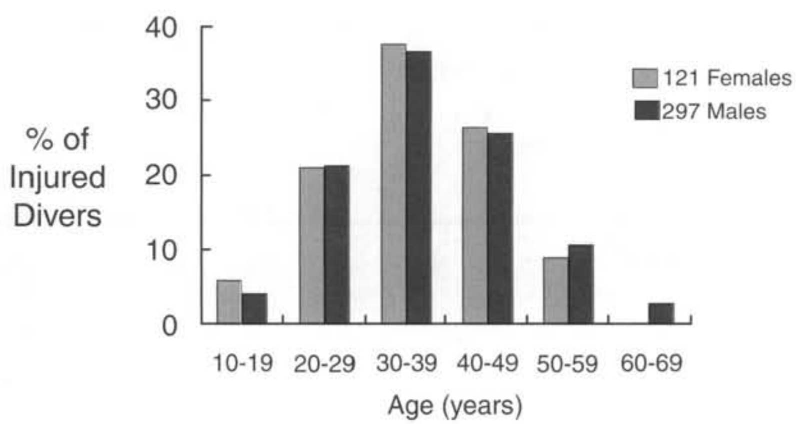
2.1 Limitations

To find missing information, DAN personnel followed up incomplete forms with the diver and the treating chamber. Delayed follow-up during the 1998-99 transition from the DARF to DIRF sometimes resulted in incomplete data. Data completeness is indicated in the text or figure captions below as percent response.

2.2 Characteristics of Injured Divers

Nearly 40% of injured divers were 30-39 years old, 5% were 10-19, and 10% were 50-59 (Fig. 23). Few injured divers were older than 60, and no divers were younger than 10. Females made up 29% of the injury population, and this varied little with age.

Figure 23. Age and gender of injured divers. (97% response)



About 80% of injured divers held Basic or Advanced certification while only 2-3% were Students (Fig. 24). About 10% were Instructors, and less than 5% were Rescue or Specialty divers. Specialty certification included cave, technical and commercial. The proportion of women was higher in the Student and Basic categories while the proportion of men was higher in the "Specialty" and "Instructor" categories.

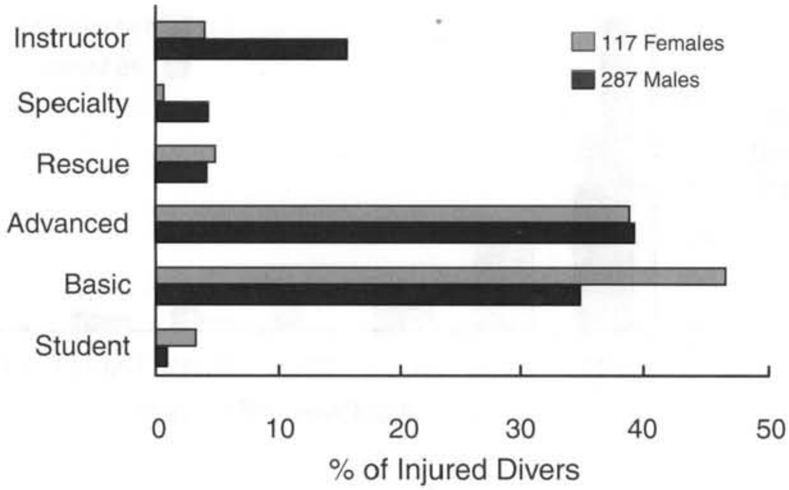


Figure 24. Certification of injured divers by gender. (94% response)

One-fifth of the males who were injured and one-third of the females had been diving for a year or less (Fig. 25). Five to 10% of injured divers were within two to five years of initial training while 15-30% were six to ten years beyond initial certification. In general, injured women had received training more recently than injured men. Time since initial training, of course, is not necessarily a good measure of diving experience or current ability.

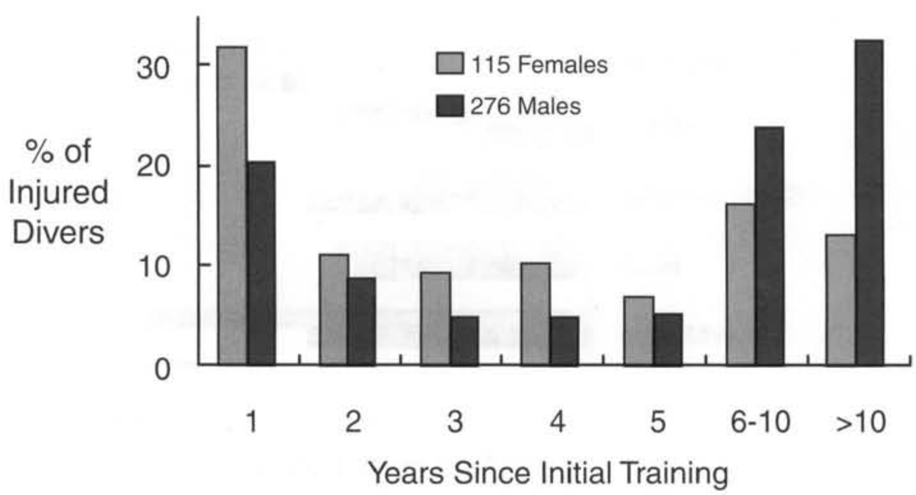
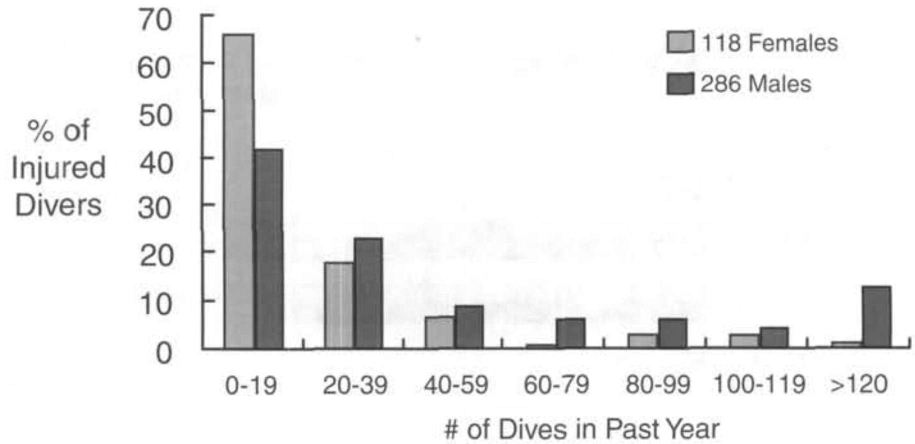


Figure 25. Years since initial training for injured divers by gender. (91% response)

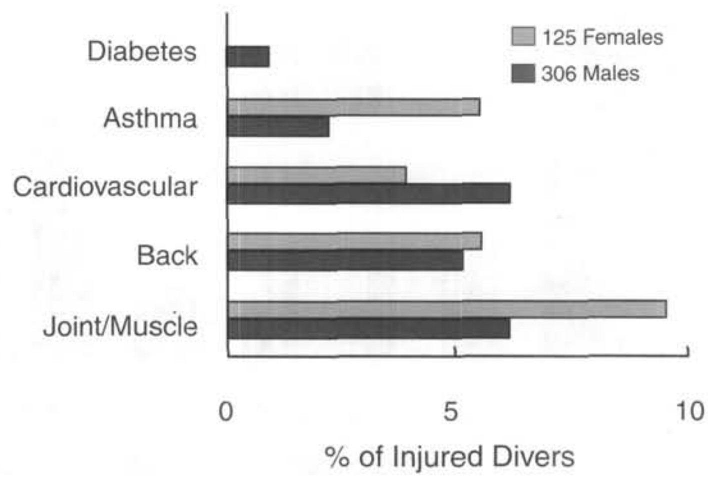
Forty percent of injured men and 65% of injured women had made fewer than 20 dives in the previous 12 months (Fig. 26). As the number of dives per year increased, the fraction of injured divers became smaller although more than 10% of injured men made more than 120 dives per year. For divers with 20 or more dives in the past year, the proportion of injured men was uniformly greater than of injured women.

Figure 26. Dives in the past year by injured divers by gender. (94% response)



Seventy-seven percent of the injured divers reported the health problems shown in Fig. 27. For 5-10%, joint, muscle, and back problems were most common. Cardiovascular problems (6%) and diabetes (1%) were more common in males than females while joint/muscle problems (9%) and asthma (6%) were more common in females. Cardiovascular problems included hypertension and heart disease. Active smoking was reported by 11.8% of injured divers. It is unknown if these factors contributed to DCI risk. One diver reported that she was pregnant.

Figure 27. Current health problems of injured divers by gender. (100% response)



All injured divers reported using some medications (Fig. 28). Decongestant used by 33-40%, were the most common drug, and one-quarter of the women were taking oral contraceptives. All other medications were used by less than 6% of the injured divers although males took more cardiovascular medications and females more asthma medications. The use of asthma medications is consistent with the reports of asthma as a health problem in Fig. 27.

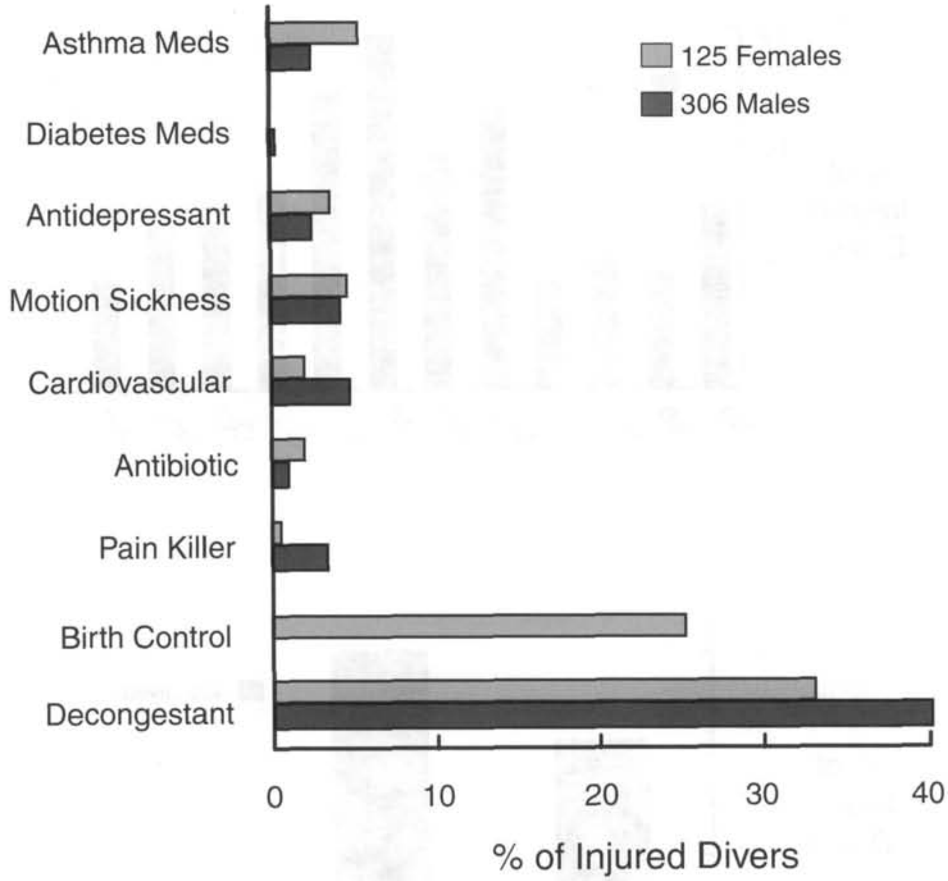


Figure 28. Medications used by injured divers by gender. (100% response)

2.3 Dives by Injured Divers

May, July, and August were the most common months for injuries (12-15% per month) while December and February to April had the fewest injuries at 5% per month (Fig. 29). Half the injuries were reported to have occurred on dives in the afternoon from noon to 6 p.m. and almost 40% in the morning from 6 a.m. to noon. (Fig. 30). Only 12% were reported to have occurred during night dives from 6 p.m. to 6 a.m.

Figure 29. Month of dives in which divers were injured. (100% response)

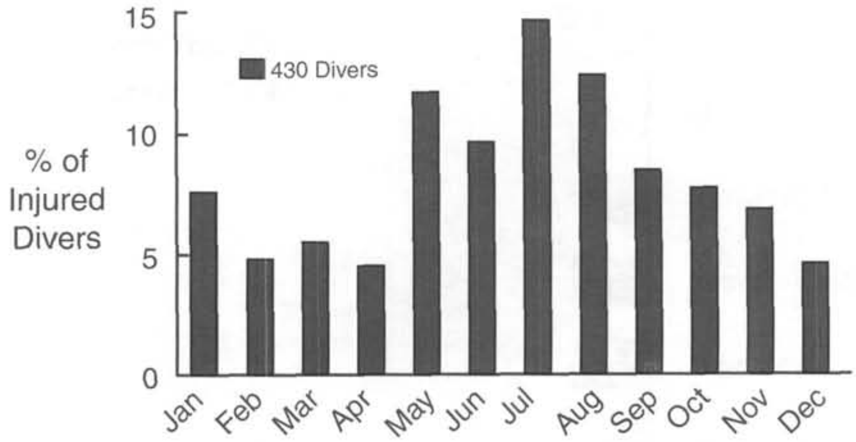
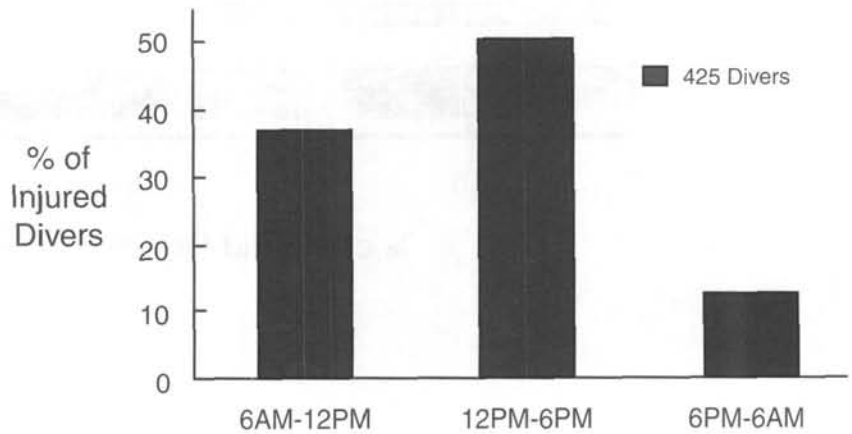


Figure 30. Time of day of dives associated with injury. (99% response)



Sixty percent of the reported diving injuries occurred in U.S. waters with the Caribbean and Latin American waters contributing 25% of the injuries (Fig. 31). The remainder occurred in more remote regions including the Pacific, Canada, U.S. Territories and the Middle East. The distribution of reported injuries in the DAN America regions is shown in Fig. 32. The majority of injuries occurred in the Southeast and Northwest regions. At 4-5% each, the Gulf and Midwest regions reported the fewest injuries.

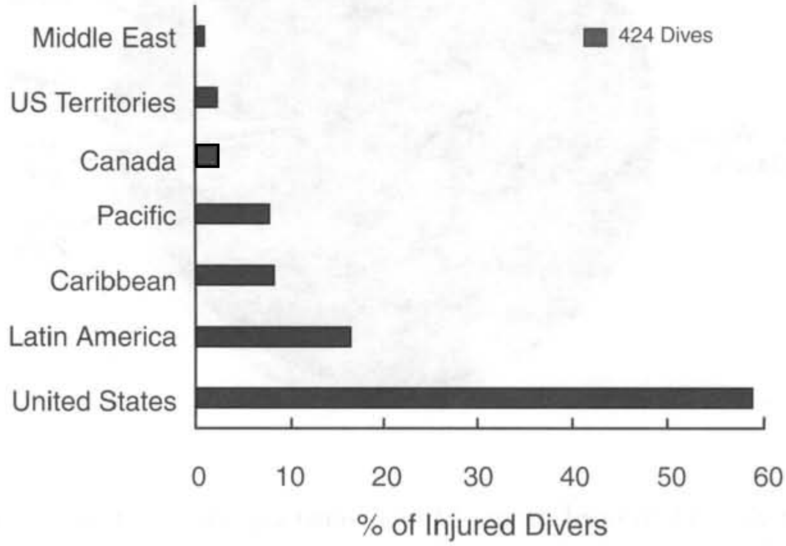


Figure 31. World regions in which diving injuries occurred.
(98% response)

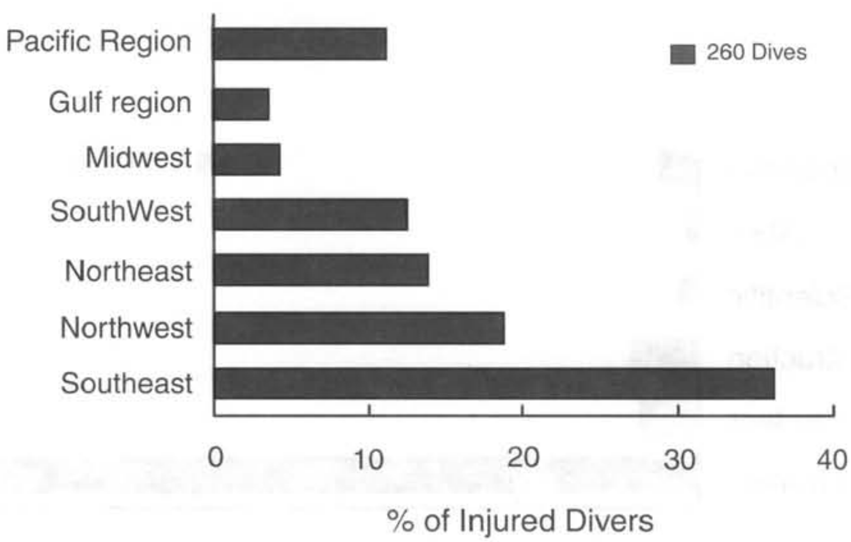
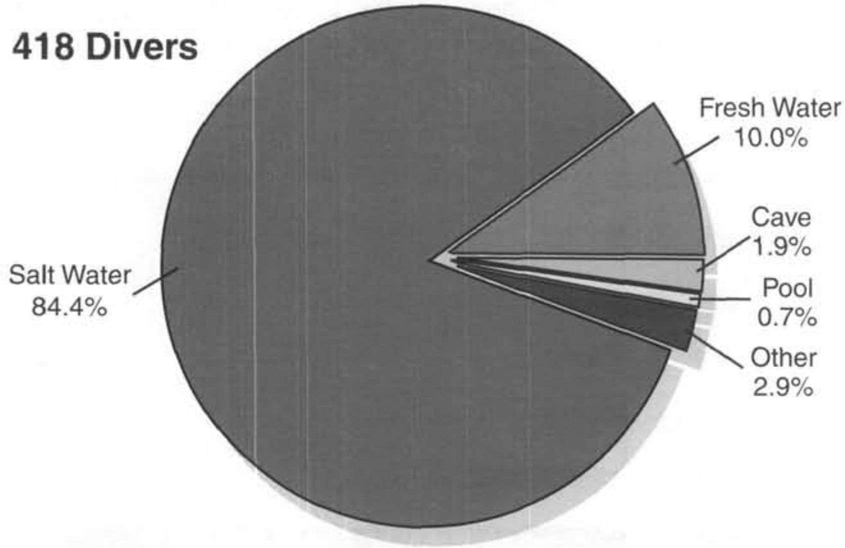


Figure 32. U.S. regions in which diving injuries occurred.
(60% response)

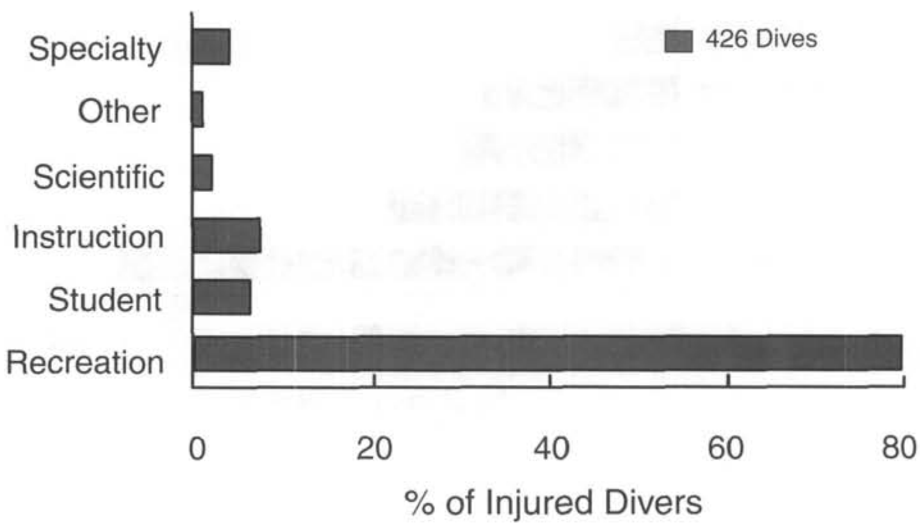
Eighty-four percent of injuries occurred in divers in salt water while 10% occurred in fresh water (Fig. 33). Rivers and streams accounted for 3% of injuries. Injuries during cave dives were reported by 2% while three divers reported being injured during pool dives.

Figure 33. Diving location at which injuries occurred. (97% response)



Almost 80% of injured divers (338 divers) reported recreation as their reason for diving. Students and Instructors made up 15% of injuries (Fig. 34). The remaining injuries occurred during scientific, specialty, or "Other" forms of diving which included law enforcement, photography and sponge collecting.

Figure 34. Reason for diving. (99% response)



The majority of injured divers (92%) used open-circuit scuba while 4.2% used closed or semi-closed scuba (Fig. 35). The remainder breathed surface supplied gas or misunderstood the choices ("Other"). Air was used by 91% of injured divers, but 6.7% used oxygen enriched nitrox, and 3% used heliox, trimix or various combinations of gases (Fig. 36). Of the 28 nitrox cases, eight reported oxygen percentages from 17-48%. Wetsuits (63%) and drysuits (15%) were used for thermal protection by most injured divers while one-third did not use thermal protection (Fig. 37). "Other" includes partial wetsuits and "shorties."

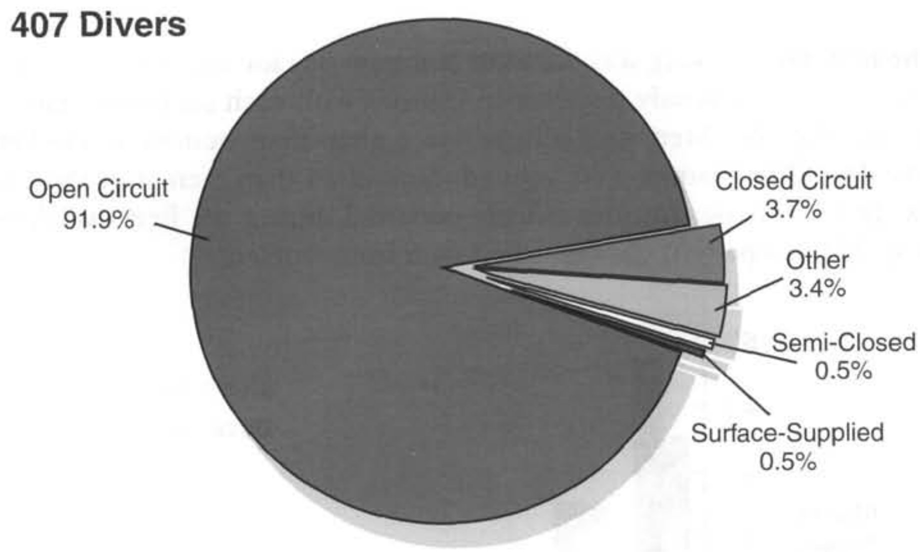


Figure 35. Breathing apparatus used by injured divers. (94% response)

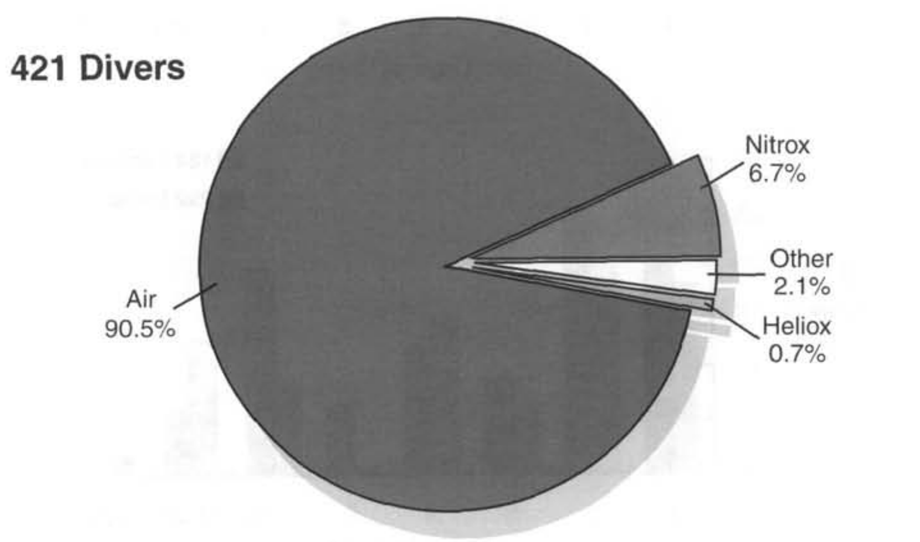
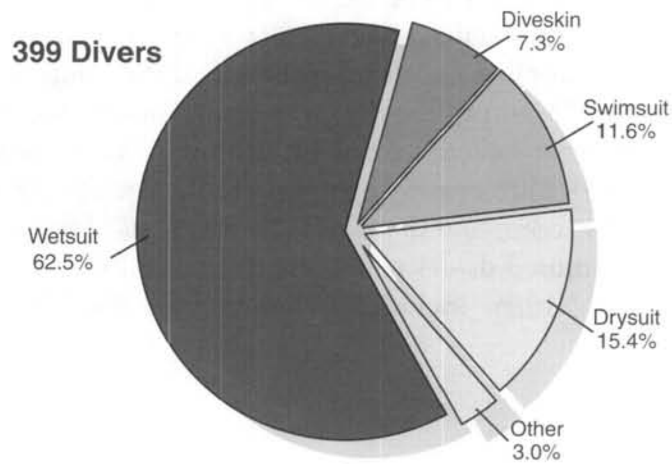


Figure 36. Breathing gas used by injured divers. (98% response)

Figure 37. Thermal protection used by injured divers. (93% response)



The first day of diving was the most common day for injuries (35-45 %), and there was a steady decrease in injuries with each successive day of diving (Fig. 38). Men were injured more often than women on the first dive day while women were injured more often than men after three to six days of diving. Injuries usually occurred during the first two dives (Fig. 39). No pattern distinguished men from women.

Figure 38. Days of diving in dive series by gender for injured divers. (97% response)

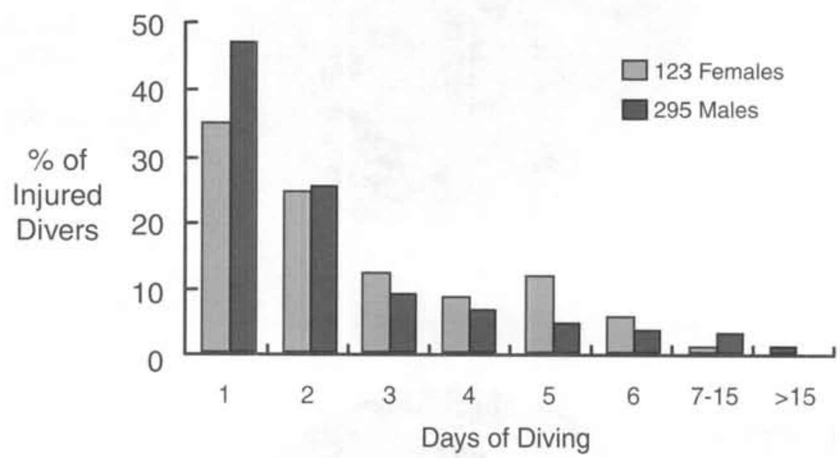
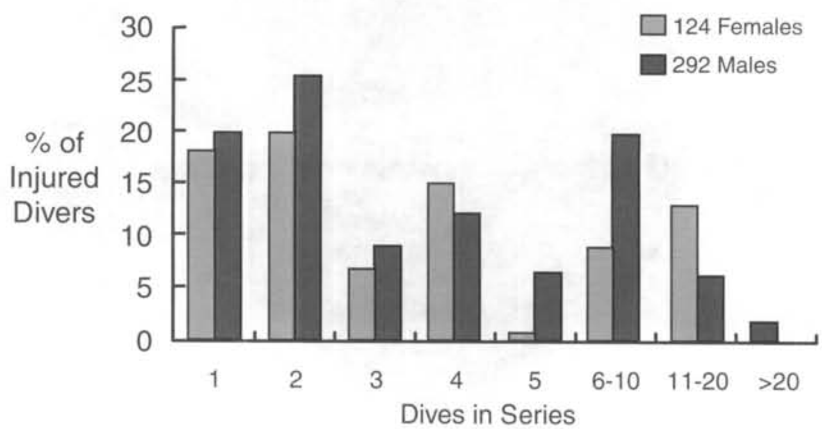


Figure 39. Number of dives in dive series by gender for injured divers. (97% response)



More than half the maximum reported depths for all dives were from 60-120 fsw (Fig. 40) while more than half the maximum depths of the last dive (the one usually associated with injury) were in a 30-90 fsw range (Fig. 41). Approximately 20% of divers injured in 1998 reported diving deeper than 120 fsw.

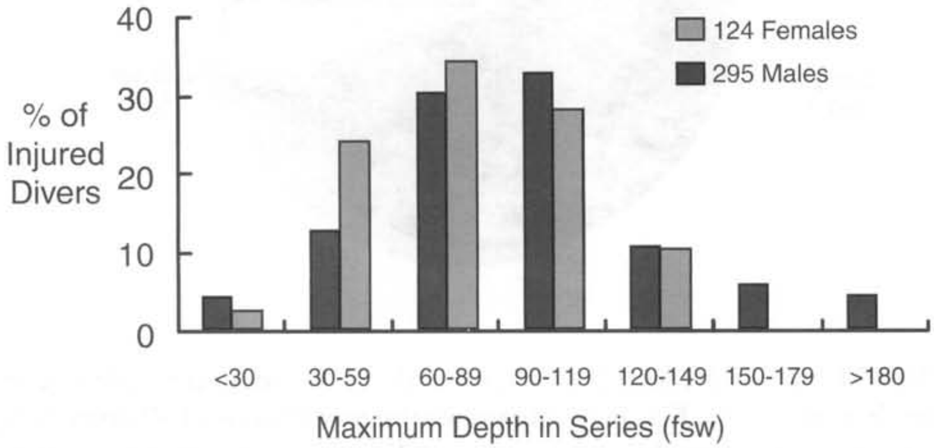


Figure 40. Maximum depth in dive series by gender for injured divers.
(97% response)

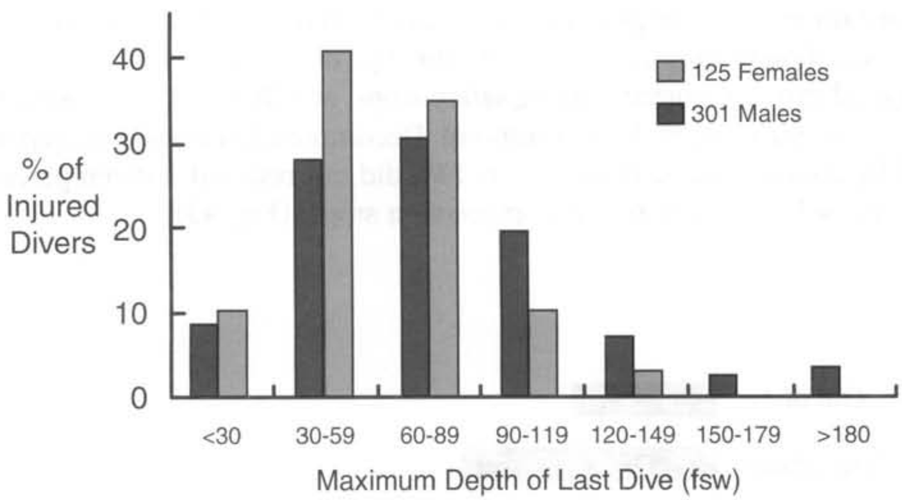
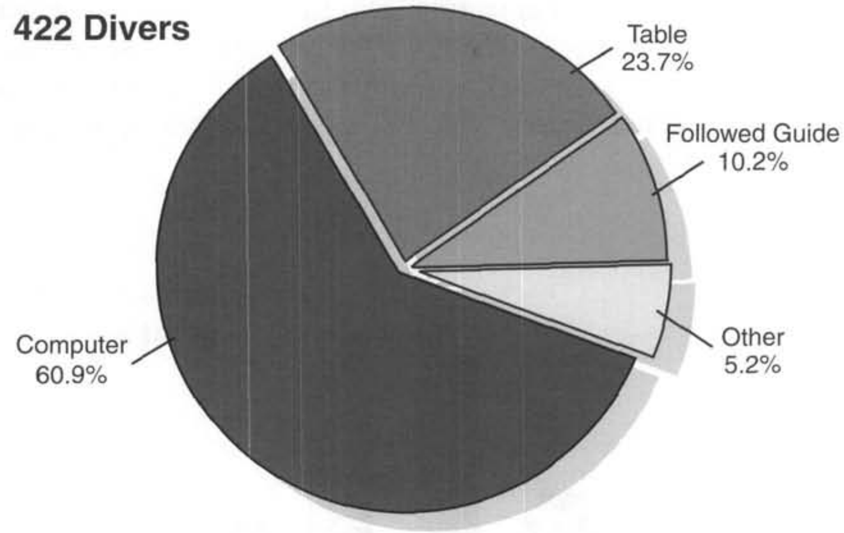


Figure 41. Maximum depth of last dive by gender for injured divers.
(99% response)

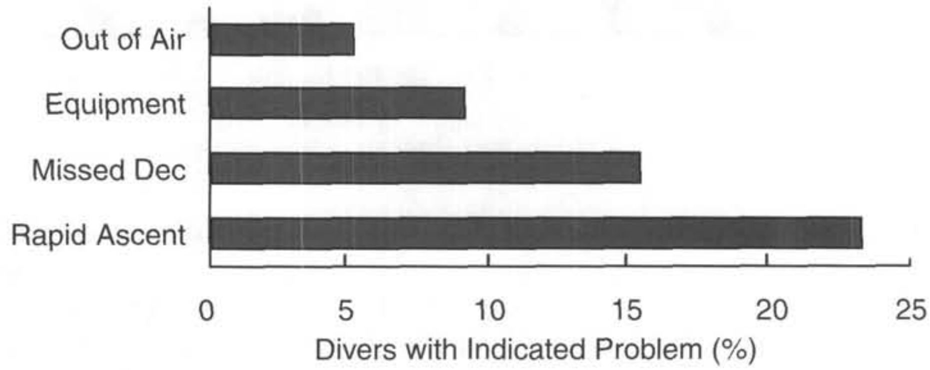
Consistent with earlier data (Fig. 12), 61% of injured divers reported using dive computers to plan their diving activity (Fig. 42) while a lesser fraction (24%) used tables (about 40% in Fig. 12), and a greater fraction (10%) followed a Divemaster or Dive Guide (less than 5% in Fig. 12). "Other," at 5%, generally represented no specified dive plan.

Figure 42. Dive planning method used by injured divers. (98% response)



The 431 injured divers reported a total of 227 procedural problems during their last dives. Figure 43 illustrates the proportions of all divers who reported equipment difficulties, missed decompression, rapid ascent, or who ran out of air. At 23%, rapid ascent was the most commonly reported problem as in the DARF data (Fig. 13) while running out of air held constant at 5%. Nine percent of injured divers reported equipment problems, although they did not specify the type of equipment. Two-thirds of injured divers reported making safety stops, and 28% did not make safety stops. Six percent did not respond. Decompression stops were reported by 25% of injured divers while 13% did not respond. Fifteen percent of injured divers omitted decompression stops. (Fig. 43).

Figure 43. Procedural problems during dives by injured divers.



One-quarter of the divers injured in 1998 reported exposure to altitude after diving (7.2% did not respond). Seven divers also reported altitude exposure between dives. These seven developed symptoms before their last dives. Excluding medical evacuation flights, data were available on preflight surface intervals for 69 divers. Of these, 20 developed symptoms during or after flights while 49 reported that symptoms occurred before flight. Figure 44 shows the percentage of injured divers who flew as a function of the preflight surface interval. About 20% of all injured divers flew with less than the 12-hr. waiting period that DAN presently recommends for flying after single, no-stop dives. An additional 45% of all divers flew within 24 hours, which is the U.S. Air Force rule for flying after diving. DAN's guideline for flying after repetitive diving is a surface interval longer than 12 hours.

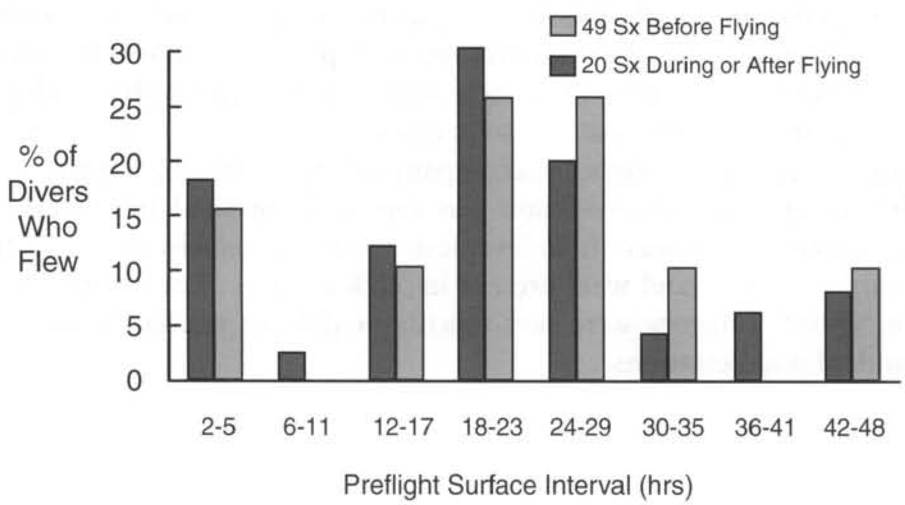


Figure 44. Flying after diving by divers injured in 1998. (93% response)

2.4 Symptoms and Diagnoses

Table 1 lists information from 1,237 symptom reports by 431 injured divers. The groupings are in general accord with the descriptive DCI manifestations. Additional information is provided by sub-groupings. Data are presented based on both cases and symptom reports. Note that the sum of the column labeled "% Cases" exceeds 100% because individual cases usually have multiple symptoms.

The neurological and pain manifestations constituted the largest groupings, each comprising 37% of all reported symptoms. Neurological manifestations occurred in 64% of cases while pain occurred in 58% of cases. There was a wide range of neurological symptoms although most of these (numbness, tingling, paresthesia, dizziness, vertigo) would be considered mild in comparison to the less common symptoms (bladder dysfunction, speech disturbance, unconsciousness, paralysis, etc.).

Constitutional manifestations (headache, fatigue, malaise, nausea, chills) made up 17% of the reports and were present in 48% of the cases, but these symptoms have many non-diving causes and are often ambiguous. Cutaneous manifestations were rare (3%). Marbling patterns on the skin is sometimes thought to accompany severe neurological symptoms. The "Lymphatic" manifestation was rare and appeared in only three cases. Cardiopulmonary manifestations were rare, usually involved difficulty breathing, and were present in 5.6% of cases. The reports listed the "Other" category were non-specific or did not readily fit into the standard manifestations.

Table 1.Symptom occurrence according to DCI manifestations. % Frequency is based on 1237 symptoms. % Cases is based on 431 cases.

Manifestation	Symptoms	Frequency	% Freq	Cases	% Cases
Neurological	Numbness/Tingling/Paresthesias	238	19.2	150	34.8
455 Reports (36.8)	Dizziness/Vertigo	84	6.8	80	18.6
274 Cases (63.5%)	Muscle Weakness/Paresis/Paralysis	41	3.3	36	8.4
	Higher Function	31	2.5	28	6.5
	Consciousness	15	1.2	15	3.5
	Eye/Vision	12	1.0	12	2.8
	Nystagmus	3	0.2	3	0.7
	Hearing	2	0.2	2	0.5
	Speech disturbance	7	0.6	7	1.6
	Gait disturbances	14	1.1	14	3.2
	Rhomberg's Sign	2	0.2	2	0.5
	Bladder Dysfunction	6	0.5	6	1.4
Pain	Limb	312	25.2	160	37.1
460 Reports (37.2%)	Trunk	81	6.5	20	4.6
250 Cases (58%)	Head	38	3.1	20	4.6
	Location N/A or not reported	28	2.3	28	6.5
	Girdle Pain	1	0.1	1	0.2
Constitutional	Headache	44	3.6	44	10.2
213 Reports (17.2%)	Inappropriate Fatigue	88	7.1	87	20.2
208 Cases (48.3%)	Malaise	5	0.4	5	1.2
	Light/Heavy Head	3	0.2	3	0.7
	Nausea/Vomiting	49	4.0	45	10.4
	General weakness	22	1.8	22	5.1
	Chills	2	0.2	2	0.5
Cutaneous (37 Reports	Itching or Rash	34	2.7	34	7.9
3%), 36 Cases (3%)	Marbling	3	0.2	2	0.5
Cardiopulmonary	Breathing problems	10	0.8	10	2.3
24 Reports (1.9%)	Shortness of Breath, Dyspnea	7	0.6	7	1.6
24 Cases (5.6%)	Cough	3	0.2	3	0.7
	Hemoptysis	2	0.2	2	0.5
	Tachypnea	1	0.1	1	0.2
	Palpitations	1	0.1	1	0.2
Lymphatic	Swelling	3	0.2	3	0.7
Other	Muscular stiffness, spasm, cramps	17	1.4	17	3.9
44 Reports (3.6%)	Pressure	10	0.8	19	4.4
53 Cases (12.3%)	Other (not specified)	14	1.1	14	3.2
	Discomfort	2	0.2	2	0.5
	Bleeding	1	0.1	1	0.2
Total		1237	100.0	431	

Table 2 describes the regional locations of symptoms involving pain, paresthesia (including numbness and tingling), muscle weakness (including paresis and paralysis) and cutaneous symptoms. Symptoms in the arms predominated except for muscle weakness where the arms and legs were equally affected. A preponderance of upper body symptoms is characteristic of decompression illness for immersed divers who are weightless as opposed to weight-bearing individuals for whom the legs are most often affected (e.g., compressed air workers, experimental subjects during altitude exposure, and saturation divers in dry chambers).

Table 2. Regional location of all symptoms associated with a location.

Region	% Pain	% Paresthesia	% Muscle Weakness	% Cutaneous Symptoms
Total Symptoms	431	234	69	48
Arms	56.4%	59.4%	29.0%	37.5%
Legs	16.0%	30.3%	30.4%	14.6%
Head	8.8%	5.1%	2.9%	8.3%
Back	7.4%	1.7%	4.3%	6.3%
Chest	4.4%	0.9%	0.0%	12.5%
General	3.7%	2.1%	31.9%	8.3%
Abdomen	3.2%	0.4%	1.4%	12.5%

Table 3 shows how symptom location is distributed among the four limbs within individual cases. The involvement of the arms over the legs is reinforced. Three-fourths of all limb pain was in the arms while weakness was almost equally distributed between arms and legs. Paresthesia and cutaneous symptoms also favored the arms.

Table 3. Distribution of affected limbs within individual cases.

Limbs	% Pain	% Paresthesia	% Muscle Weakness	% Cutaneous Symptoms
Total Cases	121	101	34	10
One arm	75.2%	49.5%	35.3%	70%
Both Arms	9.1%	13.9%	11.8%	0%
One Leg	9.1%	12.9%	14.7%	10%
Both Legs	1.7%	11.9%	29.4%	20%
Arm & Leg on Same Side	2.5%	5.0%	5.9%	0%
Arm & Leg on Opposite Sides	0.0%	5.0%	0.0%	0%
Both Arms & Legs	2.5%	0.0%	0.0%	0%
Three extremities	0.0%	2.0%	2.9%	0%

Figure 45 presents the onset times of the first symptom reported by all 431 injured divers. Nearly 20% of these symptoms occurred before the last dive, and 30% occurred upon surfacing from the last dive. Another 30% had their first symptoms within 12 hours after surfacing. About 4% of onset times longer than 20 hours represented divers who developed symptoms during or after flying.

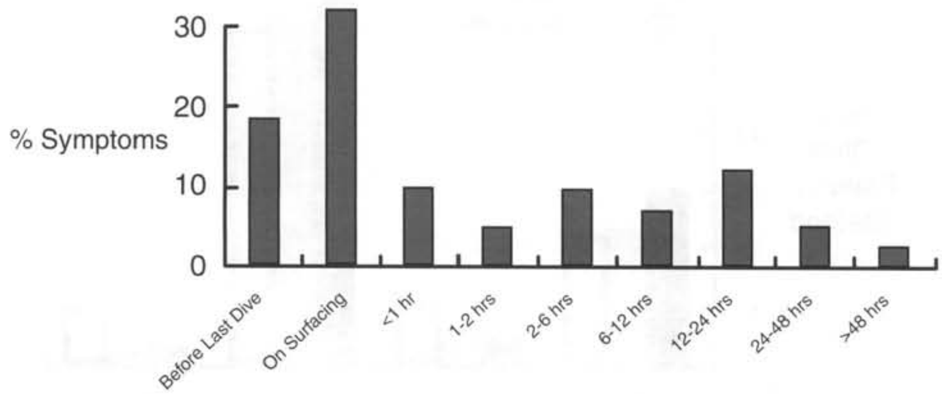


Figure 45. Onset time of first symptoms. (100% response)

Figure 46 shows the diagnoses assigned to 429 cases by chamber or DAN personnel. Nearly 60% were designated as DCS-II, 27% as DCS-I, and 5% as AGE. This is consistent with the pattern seen in previous years (Fig. 17). DCI was assigned to 3.3% of the cases while "Other" represents barotrauma, ambiguous and are not pressure-related.

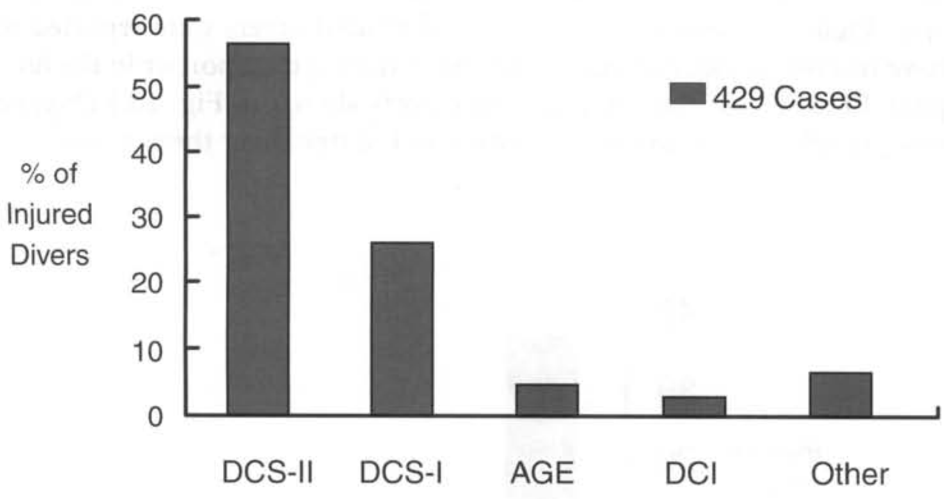
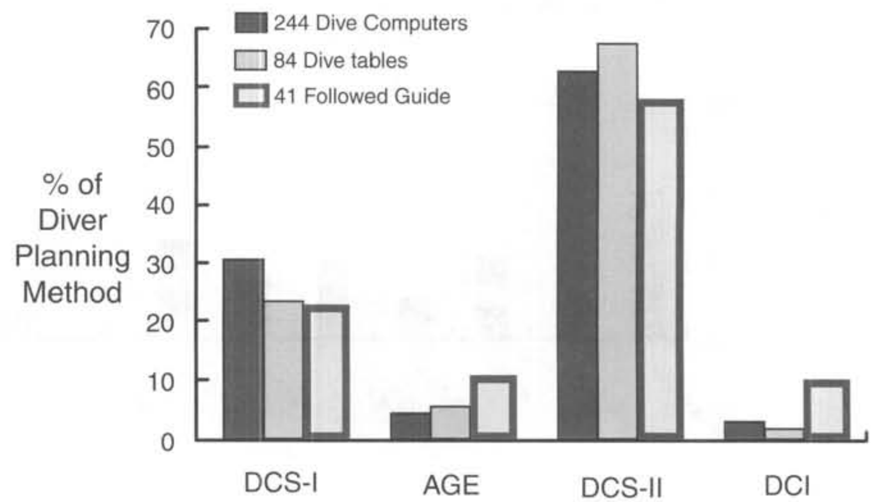


Figure 46. Diagnoses assigned to injured divers. (100% response)

Figure 47 shows how the diagnosis corresponded with the dive-planning method. Injured divers who used dive computers were more likely to be assigned a diagnosis of DCS-I and less likely to be assigned a diagnosis of AGE. This is consistent with previous years.

Figure 47. Assigned diagnosis and dive planning method. (86% response)



2.5 Therapy

First aid for divers with decompression illness included 100% oxygen at sea level, oral fluids, and aspirin (Fig. 48). Fewer than 10% were given fluids or aspirin. (It is unknown if aspirin is of any benefit in DCI therapy.) Figure 48 shows that only 37% of injured divers were reported to have received surface oxygen in the field, during transport or in the hospital. (This is less than in previous reports shown in Fig. 18.) Oxygen was provided to 18 divers (4%) twice and to one diver three times.

Figure 48. First aid given for diving injuries: oxygen, oral fluids and aspirin

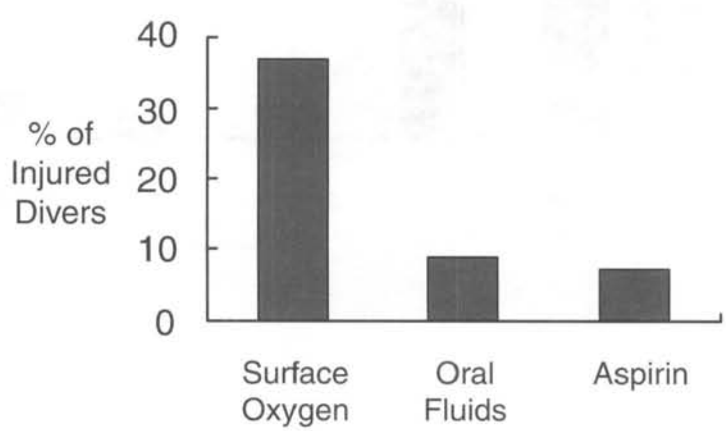


Figure 49 shows that oxygen was administered for up to three hours. The most common methods for oxygen delivery were the non-rebreather mask and the demand inhaler valve (Fig. 50) which are the preferred methods because they provide the highest inspired oxygen fractions. The oronasal resuscitation mask and nasal cannula provide lower oxygen fractions. The category "Other" represents rebreathers or chamber oxygen systems.

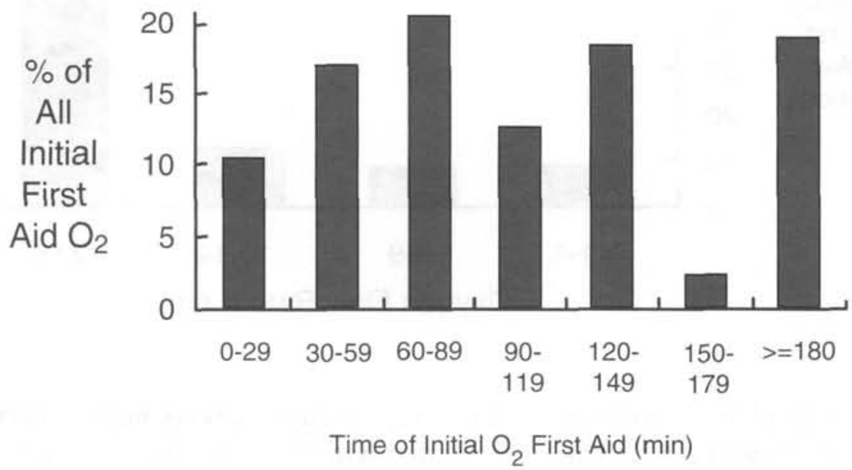


Figure 49. Duration of the initial oxygen breathing period for 136 injured divers.

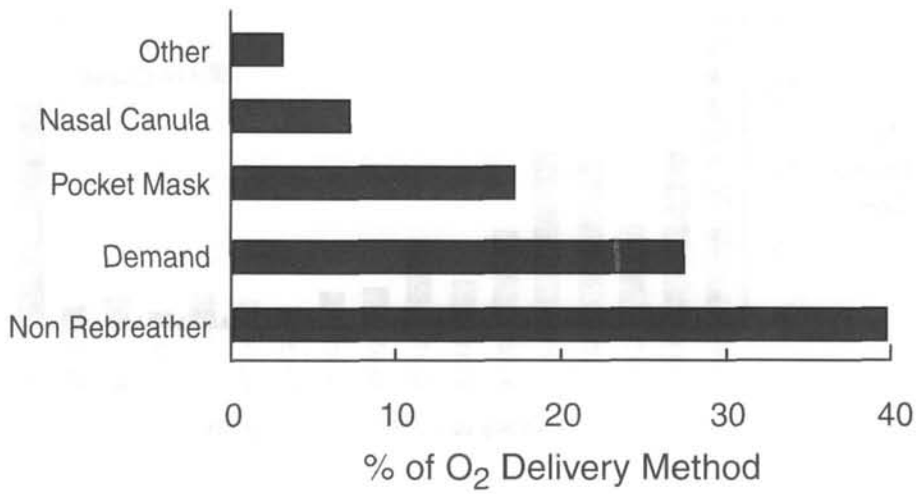
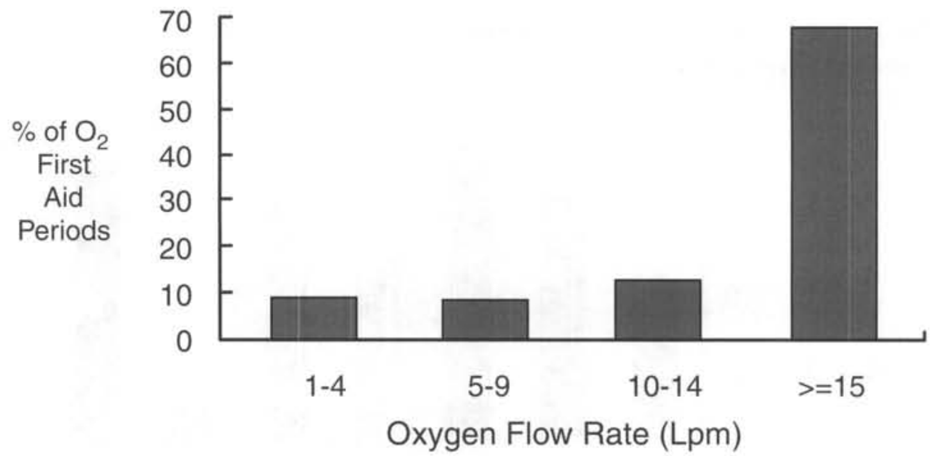


Figure 50. Method for providing oxygen to injured divers on 176 occasions.

Non-demand oxygen delivery systems were used for 110 oxygen delivery periods (Fig. 51). In 70 percent of these, the oxygen flow was set at the recommended 15 lpm or greater.

Figure 51. Oxygen flow rate to non-demand systems for 110 oxygen delivery periods.



One-fifth of injured divers were recompressed within six hours of symptom onset, and nearly half were treated within 24 hrs, but delays of two to four days or longer were common (Fig. 52).

Figure 52. Delay to recompression after symptom onset. (96% response)

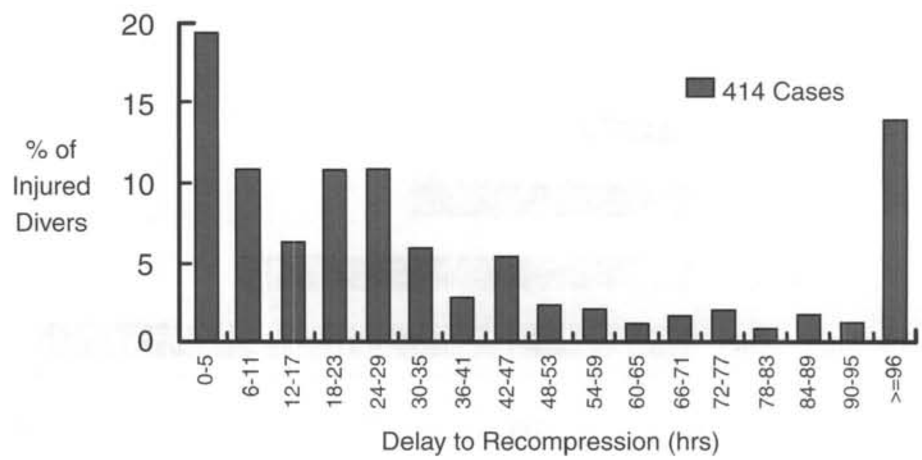


Figure 53 shows the treatment tables used for the first recompression. The distribution of first treatment table used remains the same as in Fig. 20.

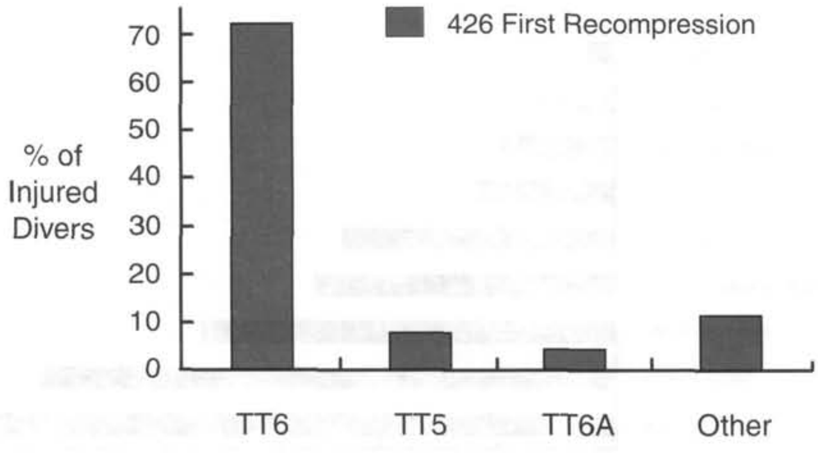


Figure 53. First recompression table. (99% response)

Figure 54 shows that a single recompression was employed in 60% of the cases and two recompressions in only 20% of the cases. A sixth treatment (USN Table 5) was used only once. The median and mean number of treatments were one and two, consistent with earlier data (Fig. 21).

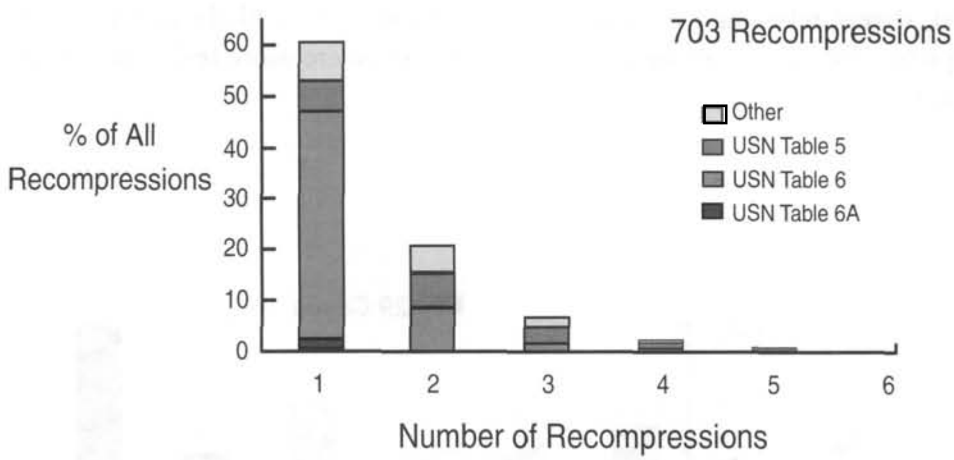
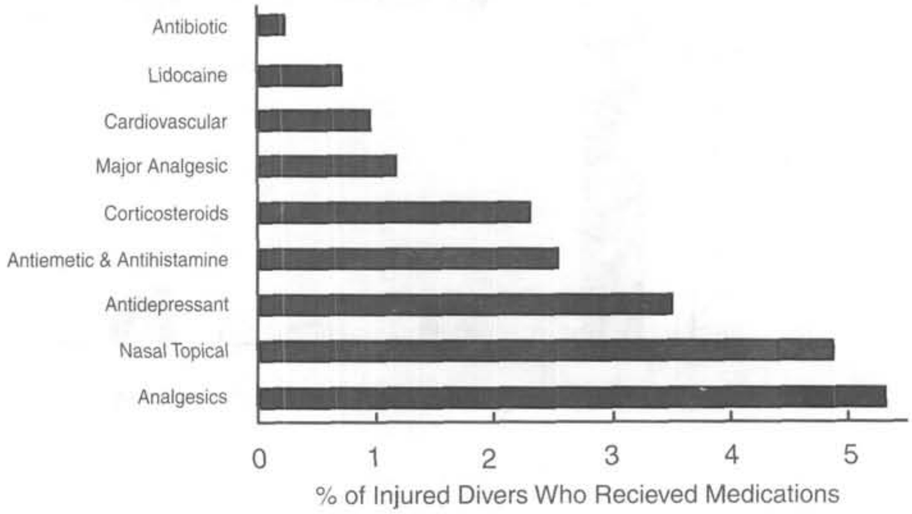


Figure 54. Number of recompressions per injured diver and treatment table used. (100% response)

At 5.3%, analgesics were the most common medications given during therapy (Fig. 55). Corticosteroids (2.3%) and lidocaine (0.7%) were administered as part of DCI therapy.

Figure 55. Medications used during therapy.



2.6 Outcome

Overall, 67.7% of 427 divers successfully achieved complete relief of their symptoms. Figure 56 shows how complete relief varied with the number of recompressions divers received. Seventy-one percent of divers who were recompressed once were completely relieved. In general, divers who received more treatments were less likely to have complete relief, probably because their symtoms were more resistant to therapy.

Figure 56. Complete relief and number of treatments. (99% response)

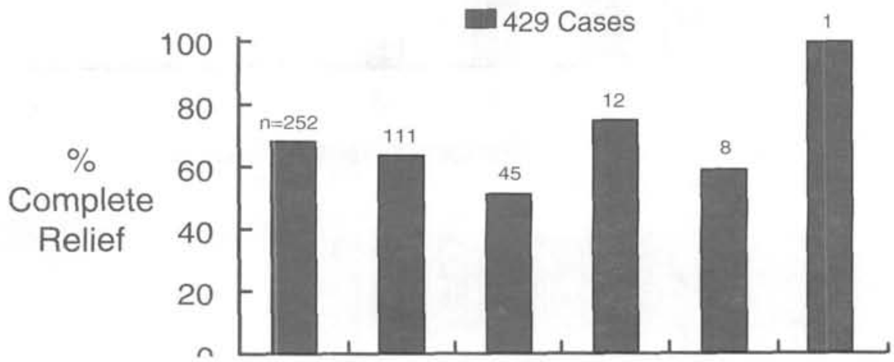


Figure 57 shows the cumulative percentages of injured divers who were treated and who had complete relief of all symptoms as a function of the number of recompressions. All divers were treated at least once and, overall, 40% had complete relief. There was a diminishing gain in divers achieving complete relief with each successive treatment. This culminated in cumulative, complete relief for 67.7% of injured divers at six recompressions.

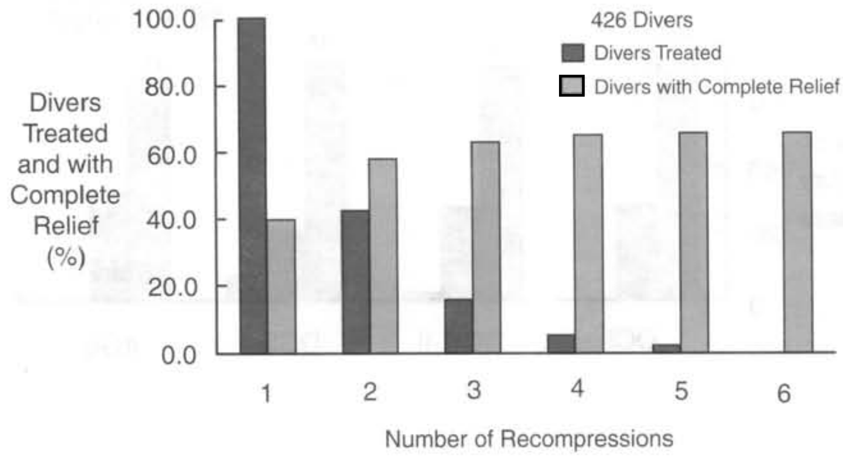


Figure 57. Cumulative relief and the number of treatments. (96% response)

Figure 58 is a similar presentation to Fig. 56 to illustrate the effect of oxygen first aid on complete relief. Of 179 divers who received oxygen before recompression, 71% had complete relief of all symptoms. Of 250 divers who did not receive oxygen before recompression, 64% experienced complete relief. For divers who received only one recompression, 76% had complete relief as opposed to 66% for divers who were not given oxygen. (The numbers above the bars represent the total number of divers who were treated under the indicated conditions, e.g., n=114 means 114 divers who received First Aid Oxygen were recompressed once.) Oxygen before recompression appeared to be less successful in improving outcome with additional recompressions although few divers were recompressed 4-6 times.

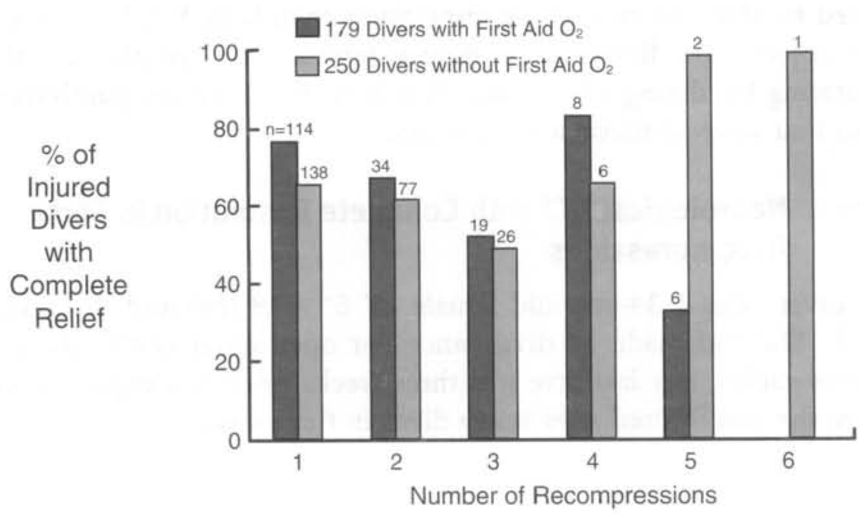
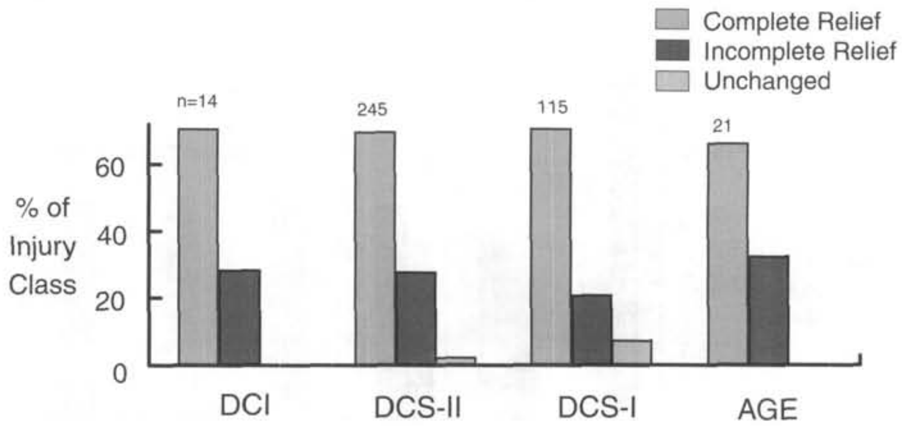


Figure 58. The effect of oxygen before recompression on the complete relief of all symptoms. (99% response)

Figure 59 shows the percentages of complete relief, incomplete relief, and no change in symptoms for the four diagnostic categories. At 70-71%, recompression was equally effective at providing complete relief for DCI, DCS-II, and DCS-I, but only 67% effective for AGE.

Figure 59. Symptom relief for each diagnostic category.



2.7 Case Reports

Approximately 1,000 U.S. citizens receive treatment annually for decompression illness in the United States and overseas. While the manifestations are varied, pain and paresthesia are the most common symptoms with fatigue, weakness, and headache often present as well. Decompression illness frequently occurs without violation of safety guidelines, and because it can mimic other diseases, divers often delay evaluation, hoping that symptoms will resolve. They often do resolve, but delayed recompression can lead to more severe symptoms or residual symptoms.

The following case reports are illustrative of the variety of DCI incidents treated by U.S. and nearby recompression chambers. While some cases have objective findings, many more exhibit diffuse symptoms that are frustrating for diving physicians. This is preferred to the paralysis and death that were common a century ago.

Case 1. Neurological Decompression Illness

Case 1. Neurological DCI with Complete Resolution in Three Recompressions

The diver was a 34-year-old female (5' 6", 118 lbs) and in excellent health. She had made 12 dives since her open-water certification two months earlier. Her last dive was three weeks prior to a trip to Mexico, where she was injured after seven dives in three days.

Her first dive, which was to a depth of 90 fsw, was followed by two shallower dives. On the second day, she made an 80 fsw dive followed by a shallower dive. She had no symptoms after the first two dive days. On the third day, she made an 80 fsw dive for 35 minutes followed by a 60-minute surface interval and a 50 fsw dive for 45 minutes.

Approximately one hour after the last dive, she developed a sense of generalized fatigue followed by an overall sense of weakness. Within a half hour, these symptoms began to interfere with her ability to stand and walk. Two hours after the dive, she contacted the dive operator and arrangements were made to take her to the local chamber.

Her weakness increased over the next two hours, and she developed a headache and general achiness similar to muscle soreness from the flu. She was recompressed four hours after the dive, with complete resolution after three treatments.

Case 2. AGE and Neurological Injury Leading to Residual Symptoms

Case 2.
AGE and
Neurological
Injury

The diver, a 45-year-old female (5' 6", 150 lbs), was in good health. She had advanced certification and had made more than 90 dives in five years, with 15 dives in the previous year. The last dive before her injury on a Caribbean vacation was four months earlier.

She began her first day with a dive to 69 fsw, which was followed by a second shallower dive. She experienced no problems or symptoms. Well-rested on the second day, she went to 88 fsw with a multilevel ascent. At about 30 fsw and 30 minutes into the dive, she made a rapid ascent as a result of a strong current and difficulty reaching the dump valve of her new buoyancy compensator, with which she was unfamiliar.

Before reaching the surface, she felt weak and unable to move her legs, and she lost consciousness soon after surfacing. When she awoke during the ride to the chamber, she began experiencing nausea, weakness and fatigue and paralysis from the waist down.

She was recompressed within one hour on an extended treatment table and had some improvement. She received a second treatment with minimal gain and remained paralyzed. After air evacuation to the United States, she underwent an additional 57 hours of recompression and improved gradually. One year after her injury, she still had weakness and numbness in her legs.

Unconsciousness immediately after a rapid ascent is associated with 50-60% of all cases in the DAN database diagnosed as AGE. Even with a rapid and aggressive treatment, signs and symptoms may not completely resolve.

Case 3. Flying After Diving

Case 3. Flying After Diving and Delayed Recompression with Complete Resolution

The diver was a 52-year-old female (5' 9", 170 lbs, post-menopausal) in treatment for mild hypertension but fit and with no other health problems. She was open-water certified, had been diving more than 30 years, and had made more than 300 dives. Her last dive was six months prior to a weeklong liveaboard dive trip that led to injury.

She performed 17 dives in six days. The first four days began with dives to depths of 90-120 fsw. She made four dives on the fourth day with no problems or complaints. Her fifth day began with a dive to 100-110 fsw, followed by a shallower second dive. On the third dive, she inadvertently followed a group of whale sharks to 147 fsw and made decompression stops as required by her dive computer. She felt well after the dive. She made her shallowest dives on the sixth day: the first to 86 fsw, a second to 74 fsw and a third to 60 fsw. All dives were multilevel and within the limits of her computer.

After waiting 48 hours before flying home to the United States, she became dizzy midway into the flight. After landing, she went to bed and returned to work the next day. Her dizziness continued, and she noticed a slight tingling and numbness in her left arm, hand and fingers. This progressed to decreased skin sensation from her left elbow to her fingertips. The dizziness continued the following day, and at times she had to support herself when standing or walking. On the third day, she felt as though she had the flu and stayed home. Her symptoms were unchanged upon return to work on the fourth day. On the fifth day, a diving physician evaluated her and she received recompression treatment. Her symptoms resolved completely within 30 minutes.

This case is noteworthy for the 48-hour surface interval before flying and the complete resolution of serious symptoms despite a five-day delay before recompression.

Case 4. A Recurrence of Pain-Only DCI with Resolution upon Recompression

The diver was a 35-year-old male (5' 11", 185 lbs) in excellent health. A divemaster, he had received certification 15 years earlier. He had made 350 dives in the past five years and 30 dives in the previous year. His last dive was two weeks prior to day of injury.

The diver made a one-day ocean excursion near his home on the East Coast of the United States. His first dive was to 115 fsw with a safety stop, and shortly thereafter, he noted pain in his left arm. The pain subsided during the surface interval required by his dive tables. His second dive was to a maximum depth of 75 fsw, and he had no difficulties until an ascent to a 10 fsw decompression stop during which the pain in his left arm returned with twice the intensity. The muscles between his shoulder and elbow and elbow and wrist were affected. Upon surfacing, he breathed 100% oxygen with little improvement. The pain persisted through the afternoon and evening; this led him to a local emergency room and recompression chamber. The pain resolved within 10 minutes of recompression.

There are many causes of pain, but DCI should be suspected if pain occurs after diving. On should seek medical evaluation by a diving physician as soon as possible. Early recompression offers the greatest possibility for full recovery and return to diving.

Case 4. Pain-Only Decompression Illness

Case 5. Pain-Only DCI, Flying with Symptoms, Delayed Treatment, and Complete Resolution

The diver was a 31-year-old male (6'1", 300 lbs) in good health. He had had knee surgery three years earlier. He was a basic open-water diver certified 10 years before, but he'd had only 20 dives and no diving for two years. His injury occurred during a five-day island vacation during which he made seven dives.

His first dive was to 50 fsw for to familiarize himself with diving. During the next three days, he made one to two dives per day to 70-80 fsw. All of his dives included a safety stop at 15 fsw. On his last day, he made a multilevel computer dive to a maximum depth of 90 fsw with a total time of 40 minutes. This dive was complicated by rapid ascent from the 15 fsw safety stop, but there were no symptoms.

Approximately 20 hours after his last dive, he noticed bilateral elbow discomfort which gradually progressed to both wrists. In the afternoon, he developed bilateral knee and ankle pain and, finally, an ache in his left shoulder. The pain in his left wrist was fairly severe. He had performed no physical activity that might explain his symptoms.

Case 5. Pain-Only Decompression Illness, Flying with Symptoms

Approximately 36 hours after his last dive and 16 hours after symptom onset, he flew home. His symptoms were present throughout the flight, their intensity did not increase. After a day at home and four days after symptom onset, he called his physician who referred him to a local recompression facility. A neurological examination was normal, and he was recompressed twice in two days with complete relief.

Case 6. Flying with Symptoms

Case 6. Flying with Symptoms and Resolution upon Recompression

The diver was a 24-year-old male in excellent physical condition without medical problems. He had recently received certification and had made fewer than 10 dives. During a Caribbean dive vacation with several friends, he made 14 dives in five days without problem and did safety stops on all dives. On the last day, he made a single dive to 65 fsw for 45 minutes, exiting the water mid-morning.

Approximately eight hours after his final dive, he felt mild bilateral knee pain which gave him little concern. The following morning he noticed gradual onset of bilateral pain in the joints of his hands and fingers. He flew home later that day, some 27.5 hours after his last dive. During the flight, he developed bilateral elbow tenderness and decreased skin sensation in his left lower leg to the middle of his left foot.

After a day at home with no change in his symptoms, a local hyperbaric physician evaluated him, and he had complete relief during a single recompression.

Case 7. Neurological Decompression Illness with Multiple Treatments

Case 7. Neurological DCI with Multiple Treatments and Gradual Recovery

The diver was a 46-year-old (5'7", 145 lbs) male in good general health. He had not smoked or consumed alcohol, and he had exercised on a regular basis. He was an open-water diver and had been certified for three months. He had made 12 dives, the last being several weeks earlier. He was on his first Caribbean vacation.

The first day of diving involved two uneventful, multilevel dives to 100 fsw with a one-hour surface interval, ascents according to a dive computer and safety stops. The following day he made a multilevel dive to 120 fsw for 28 minutes with a two-minute safety stop at 10 fsw. After a one-hour surface interval, he made a second, multilevel dive to 120 fsw for 37 minutes with a five-minute safety stop at 15 feet. After a second one- hour surface interval, he made a 100 fsw multilevel dive for 58 minutes with a five-minute safety stop at 15 feet. All dives were uncomplicated and without problems. Asymptomatic for the remainder of the day, he went to bed without symptoms.

On awakening the following morning, the diver noticed a nagging pain in his left shoulder, with numbness in his forearm from elbow to wrist and numbness down the left side of his face. As the symptoms seem to increase in severity during the next four hours, he visited the local island physician who found decreased sensation on the left side of the face and the left forearm. The left side of the diver's mouth was also weak. He was recompressed six hours after waking with symptoms.

The forearm numbness completely resolved with an extended hyperbaric oxygen treatment, the shoulder pain diminished by half and the facial numbness was greatly reduced. A second treatment resolved all pain and further improved the tingling on the left side of the face. With a third treatment, he experienced a slight additional improvement, but with the fourth and last treatment, he experienced minimal improvement. The remaining numbness resolved after 24 hours.

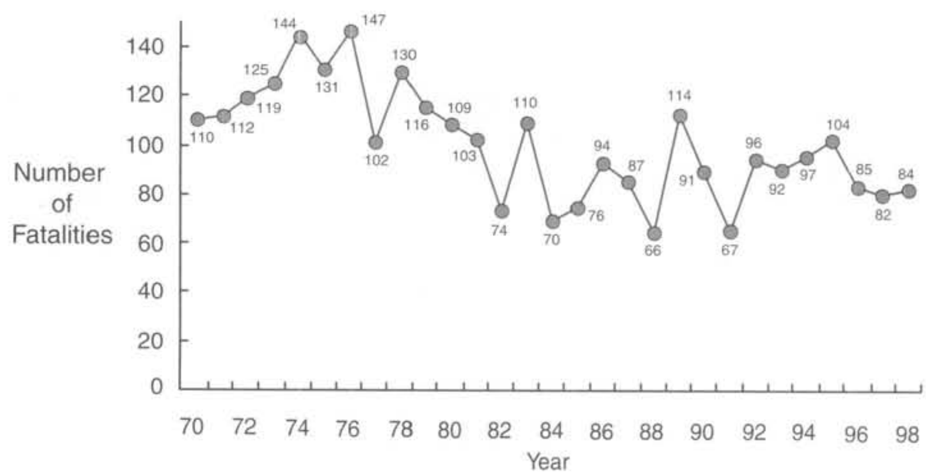
1989-1997 Diving Fatality Trends

John J. McAniff of the University of Rhode Island began collecting information about recreational diving fatalities in 1970. In 1989, DAN joined the collection process, working with McAniff until his retirement in 1995.

DAN pursues all fatality reports that appear to involve recreational divers. Data collection often begins with a telephone call or newspaper clipping that informs DAN of an event. This starts a process in which DAN contacts witnesses or family members and official investigative agencies, such as the Coast Guard, police departments, coroners, medical examiners, hyperbaric chambers or diving agencies.

Figure 60 shows the number of fatalities reported for 1970-98. While annual fatalities have fluctuated widely from a 1976 high of 147 to a 1988 low of 66, a decrease occurred through the early 1980s although recent numbers have fluctuated around 80 deaths per year. DAN began to keep diving fatality records in 1989. Summaries of data for 828 diving fatalities from 1989 to 1997 are presented below. The 1998 fatalities are described in detail in Section 4 (pg. 68).

Figure 60. Diving fatalities from 1970 through 1997. The number of annual deaths is indicated next to the graph.



3.1 Diver Characteristics in Diving Fatalities

Figure 61 shows that the mean age at the time of death varied from 38 to 42, with a trend toward increasing age during the reporting period. A similar trend was noted for divers with non-fatal injuries (see Fig. 5, Section 1), although injured divers were about four years younger than those who died. Approximately 80% of divers who died were male (Fig. 62), slightly more than males who suffered diving injuries (Fig. 6, Section 1). There were correspondingly fewer fatalities among females than there were injuries.

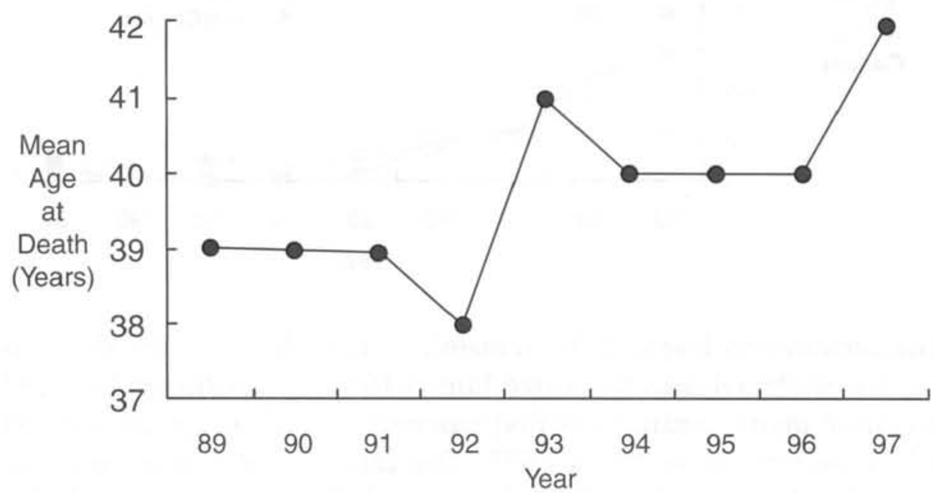


Figure 61. Mean diver age at time of death from 1989 to 1997.

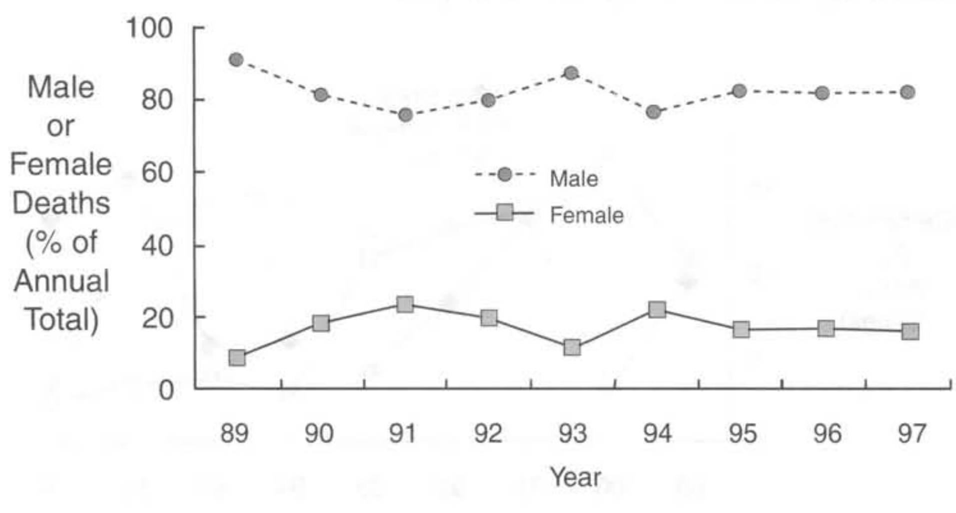
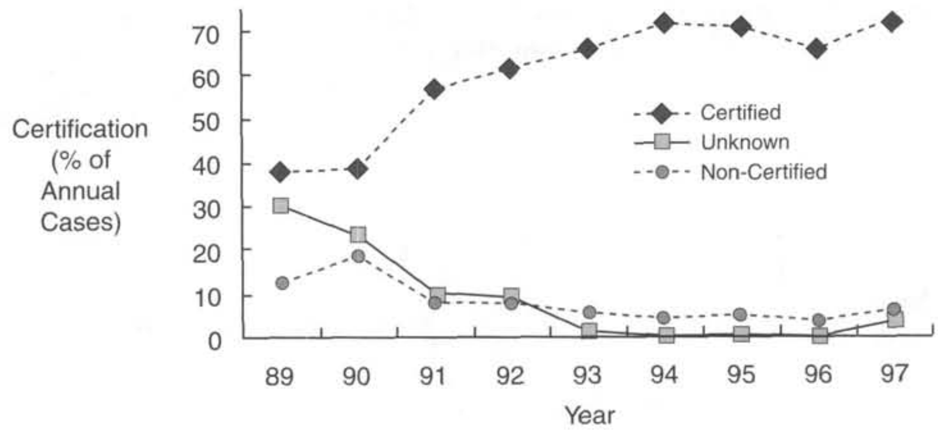


Figure 62. Male and female deaths from 1989 to 1997.

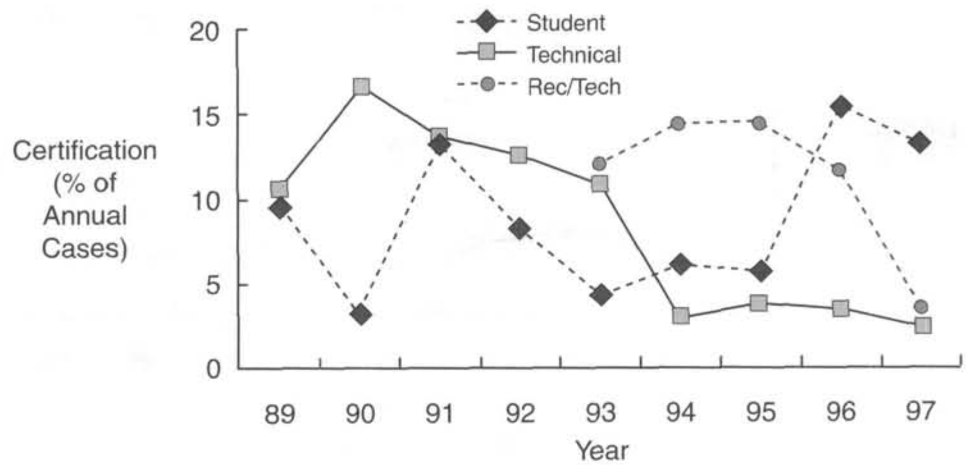
Figure 63 shows that certified divers have increased from 40% of diving fatalities in 1989 to a nearly constant 70% by the mid-1990s. A corresponding decrease occurred in fatalities of unknown certification, from 30% to nearly 0 percent. Fatalities of non-certified divers have decreased from 10-15% to 5%. (Note that the percentages in Figs. 63 and 64 sum to 100%.)

Figure 63. Certification of diving fatalities



The certification levels of the remaining diving fatalities are shown in Fig. 64. Student deaths fluctuated from 3-15% with no discernible trend. Technical diving deaths were first reported in 1993 and peaked at 15% before decreasing to 3% in 1997. The category "Rec/Tech" indicates recreational divers who did not have the skills or training to make the technical dives which led to their deaths. Rec/Tech fatalities declined from a high of 16% in 1990 to 3% in 1997.

Figure 64. Certification of student and technical diving fatalities.



3.2 Definition of Technical Diving

The definition of technical diving is evolving and has no well-recognized standard, but the following observations are relevant:

- Dr. Bill Hamilton used the term "high-tech diving" in Issue #1 of *AquaCorps* (January 1990).
- The term "technical diving" was introduced in Issue #3 of *AquaCorps* (January 1991) by Michael Menduno as an analogy to "technical climbing."
- The original definition of technical diving in *AquaCorps* Issue #3 was:
  - A discipline that uses special methods, equipment and training to improve underwater safety and performance, enabling divers to explore a wide range of environments beyond the scope of recreational diving. This definition included cave diving, decompression diving and overhead wreck penetrations.
  - At the 1999 AAUS meeting, Dr. Hamilton proposed a simpler definition of technical diving: any dive involving a gas switch.

Technical diving requires appropriate training, experience and planning.

For the purposes of this report, DAN defines a technical dive as:

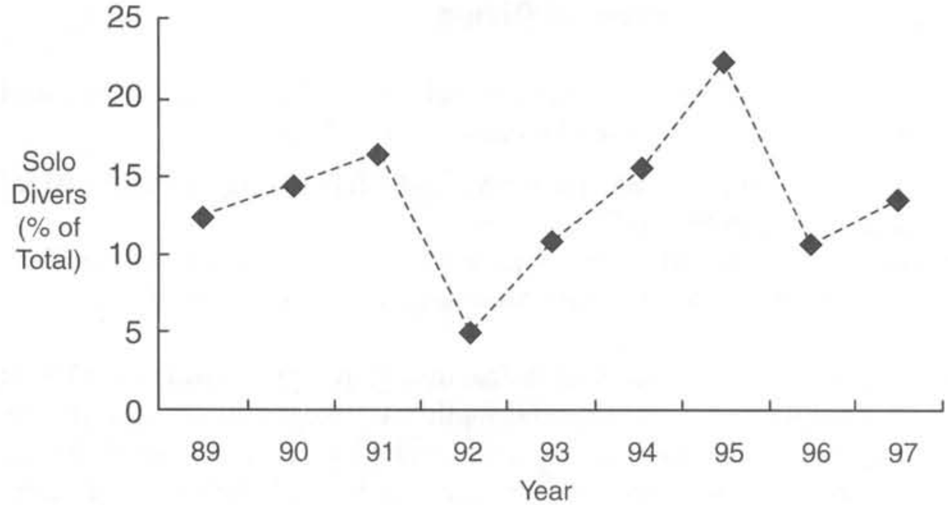
- A dive in which the composition of the breathing gas is changed either by the diver switching gases or by automatic adjustment in a rebreather.
- A dive with real or virtual overhead environment such as a cave, wreck or a planned decompression.
- A dive outside the *de facto* definition of recreational diving, which is:
  - No-stop, repetitive, compressed air, open-circuit scuba diving to no deeper than 130 fsw.
  - Enriched air nitrox is becoming widely used and may someday become part of this definition.
- Technical diving requires appropriate training, experience and planning.

DAN will reassess its definition of technical diving annually.

3.3 Dives Associated with Diving Fatalities

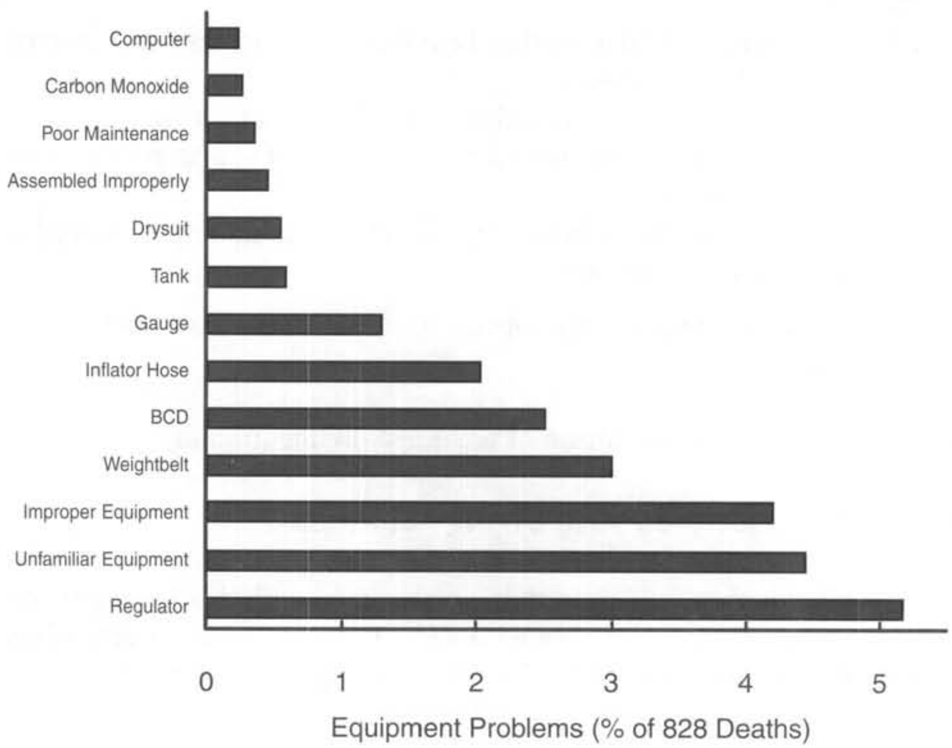
Little is known about diving activities associated with deaths. Figure 65 shows the percentage of divers who were without a dive buddy when they died. This ranged from 5-22%. No trends are apparent.

Figure 65. Fatalities among solo dives.



The diver's equipment is often checked during the formal fatality investigation, which may include gas analysis. The most commonly reported equipment problems were with the regulator, weight belt or buoyancy compensator, and with unfamiliar or improper equipment (Fig. 66). These occurred in 2.5-5% of the 828 fatalities during 1989-97. Some fatalities had multiple problems.

Figure 66. Problems associated with equipment in diving fatalities.



Problems associated with equipment noted in Fig. 66 may have caused the deceased divers to lose buoyancy control, run out of air or ascend rapidly. Figure 67 shows the occurrence of these diving problems. Deceased divers who ran out of air decreased from 65% in 1990 to 20% in 1997. By comparison, only 5% of injured divers ran out of air (Fig. 13). Buoyancy problems and rapid ascent were reported in 10-20% of fatalities. Buoyancy problems and rapid ascent were reported in 20-30% of diving injuries (Fig. 13).

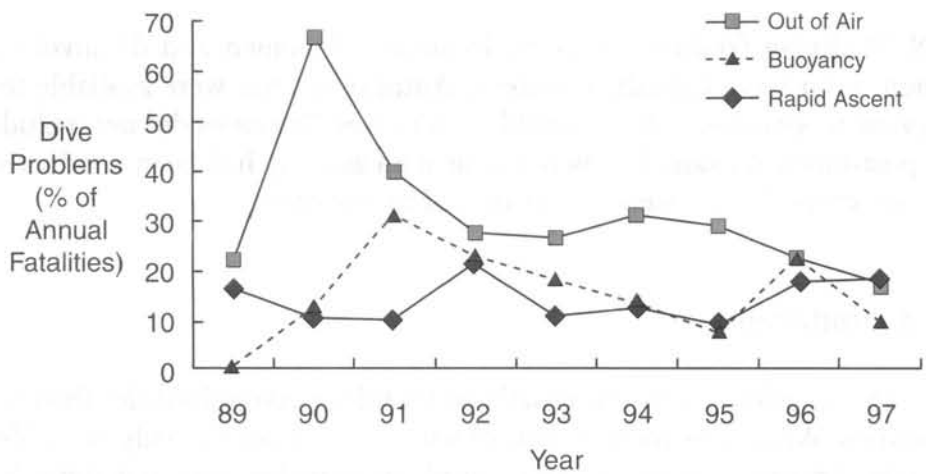


Figure 67. Out of air, buoyancy problems and rapid ascent in diving fatalities.

3.4 Causes of Death

Drowning, the primary reported cause of death, varied from 50-70% during the reporting period, but drowning is uninformative as to factors leading to death. Drowning is often a diagnosis of exclusion when other causes of death are unknown. Figure 68 describes those causes to which specific deaths could be attributed. Cardiovascular factors were found in 6-14% of diving fatalities, with an average of about 10%. Arterial gas embolism was reported in 5-14%, with an average of about 8% although a high of 14% occurred in 1997. Decompression sickness varied from 0-2% with an average of 1%.

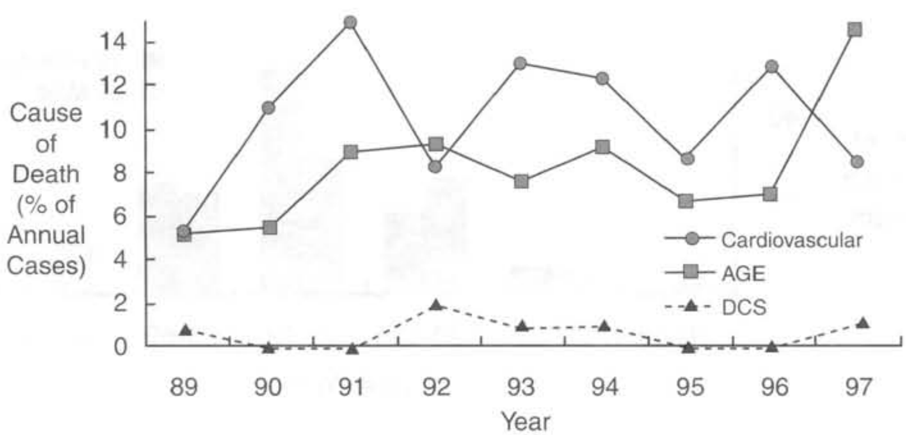


Figure 68. Causes of death in diving fatalities.

1998 Diving Fatalities

Diving fatalities are almost always categorized as non-natural deaths unless another cause can be determined. In most states, the medical examiner assumes jurisdiction, and autopsies are at his or her discretion. DAN recommends autopsies for all diving fatalities and accidental drownings.

Of 83 diving fatalities in 1998, 16 involved women and 67 involved men. Four were Canadian citizens. Autopsy reports were available for review in 49 cases and unavailable in 13 cases. Ten cases did not include a post-mortem exam. It was not clear if an autopsy had been conducted in six cases. Bodies were not recovered in five cases.

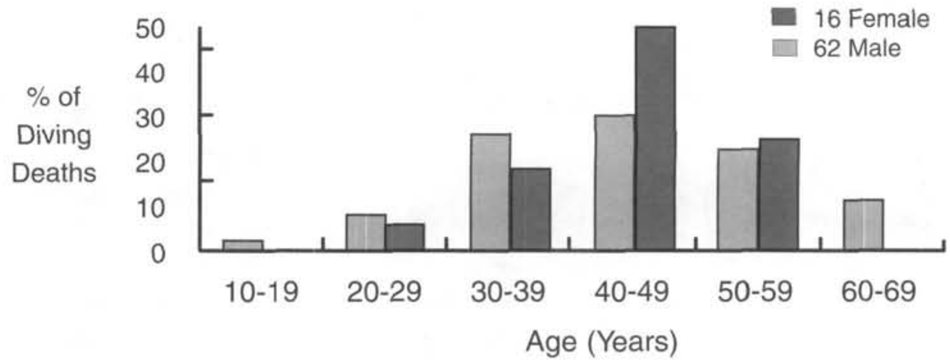
4.1 Limitations

Much less information can usually be found for diving fatalities than for injuries. While first-hand reports of witnesses are occasionally available, fatality victims cannot be interviewed. Information can sometimes be gathered only through news reports, and some cases are sealed due to legal action.

4.2 Diver Characteristics in Diving Fatalities

The most common ages for both male and female fatalities in 1998 were ages 40 through 49. (Fig. 69). This is 10 years older than the most common ages of injured divers (Fig. 23). The greatest proportions of diving fatalities held basic certification (Fig. 70) similar to injured divers (Fig. 24), but student and non-certified divers were more common among fatalities than injuries.

Figure 69. Age and gender of diving fatalities. (94% response)



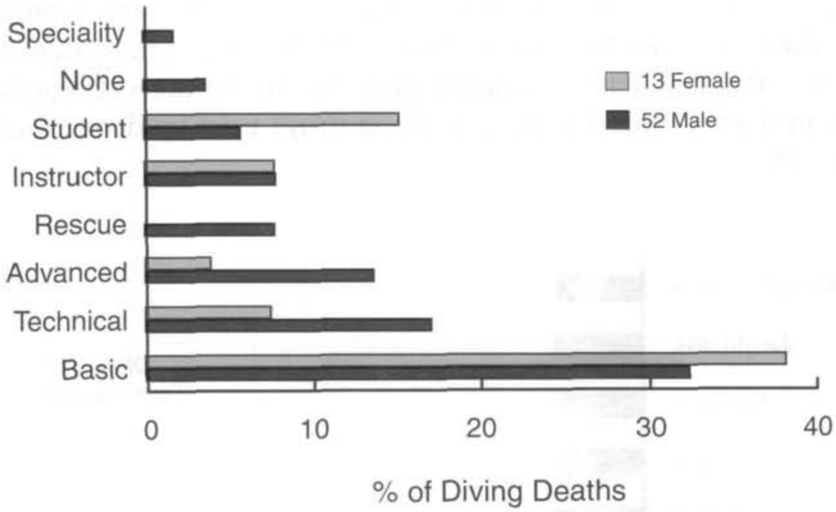


Figure 70. Certification of diving fatalities by gender. (78% response)

Of diving fatalities for whom data were available, 60% of women and 40% of men had been certified to dive less than one year earlier (Fig. 71). Only half the injured divers were trained this recently (Fig. 25). The importance of current diving experience is also suggested by Fig. 72, which shows that 60% of male fatalities and 80% of female fatalities for whom information was available had not been diving in the previous year.

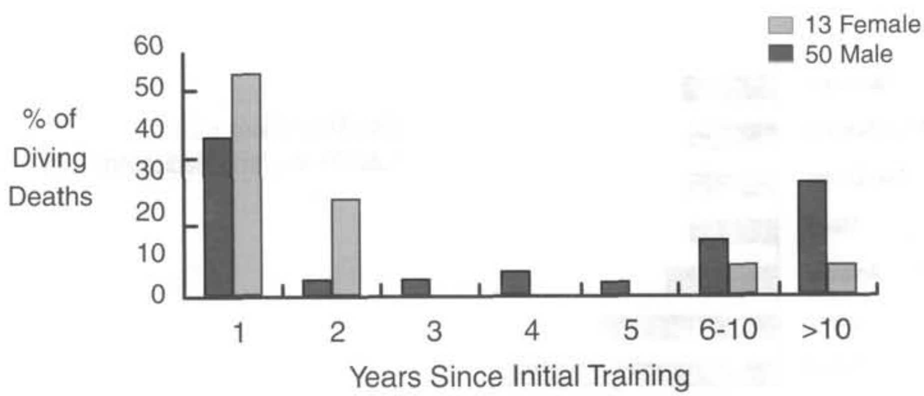


Figure 71. Years since initial training for diving fatalities by gender. (76% response)

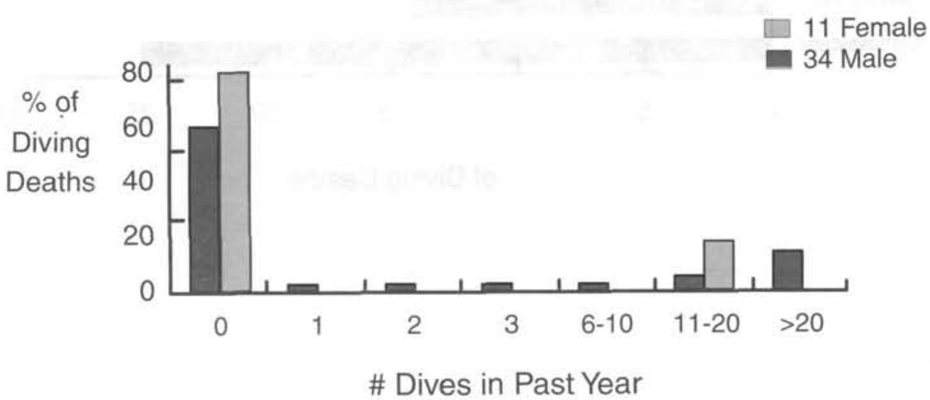


Figure 72. Dives in past year for diving fatalities by gender. (54% response)

Nineteen divers out of 46 for whom data were available were reported to have the health problems shown in Fig. 73. At 15%, cardiovascular disease was the most common health problem. Medications for cardiovascular problems were the most common drugs used by diving fatalities (Fig. 74).

Figure 73. Health problems of diving fatalities. (55% response)

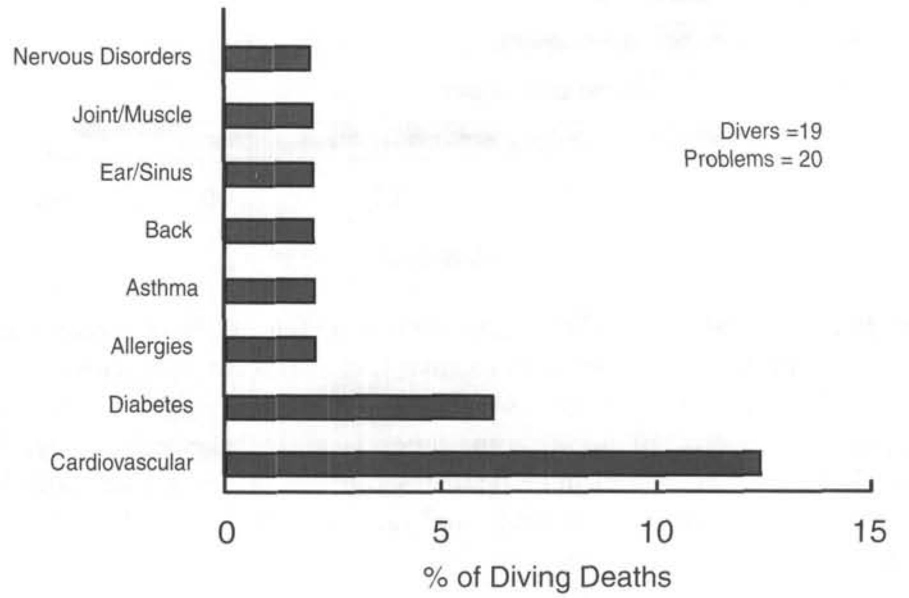
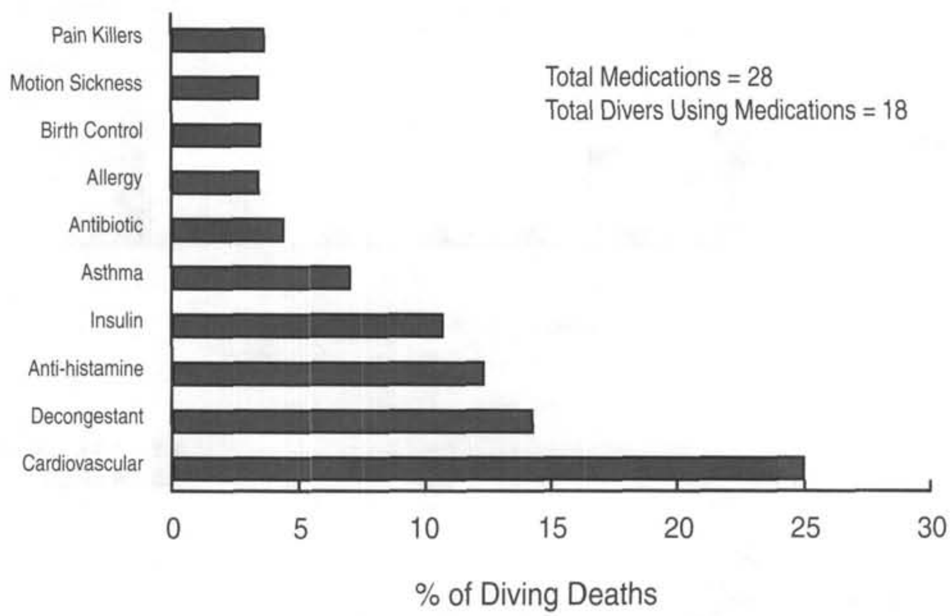


Figure 74. Medications used by diving fatalities. (58% response)



4.3 Dives Associated with Diving Fatalities

Summer was the most common season for diving fatalities (Fig. 75) as was the case for diving injuries (Fig. 29). Based upon the 41 fatalities for whom data were available, 60% died in the afternoon and 30% in the morning (Fig. 76). The United States was the site of death for more than 70% of the divers (Fig. 77), while of those who died in the United States, nearly a quarter were from Florida and 10% from California (Fig. 78).

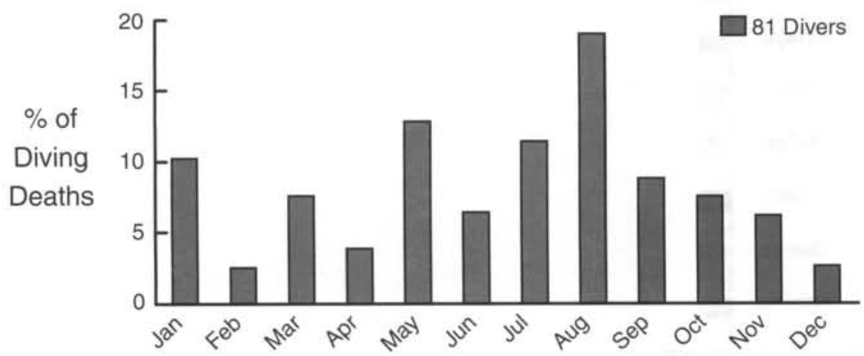


Figure 75. Month of dives by diving fatalities. (98% response)

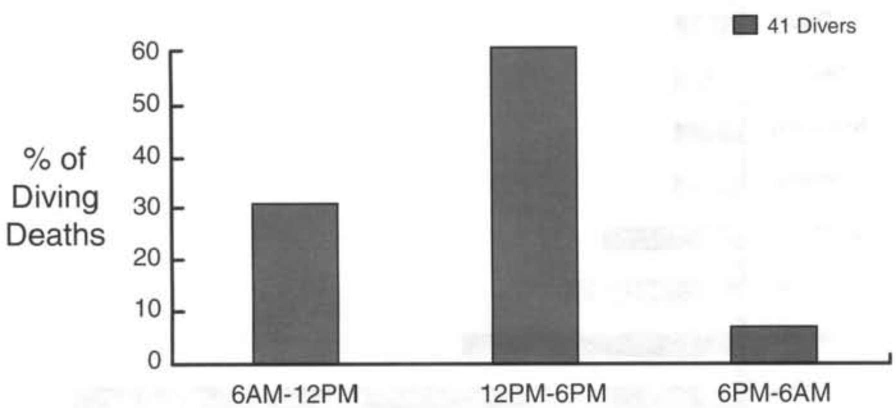


Figure 76. Time of day at which diving fatalities occurred. (49% response)

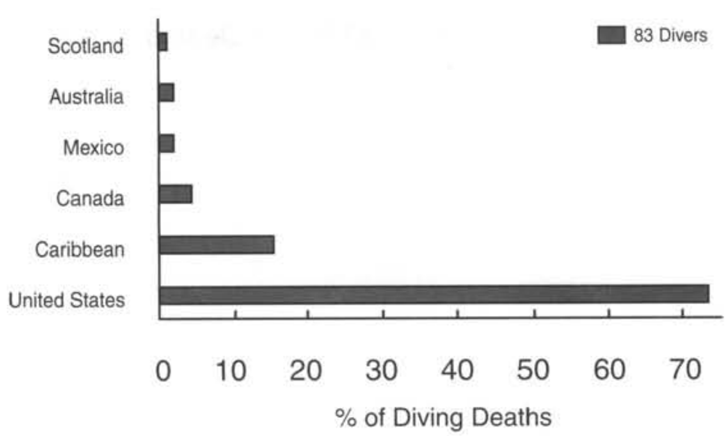


Figure 77. World region in which diving fatalities occurred. (100% response)

Figure 78. U.S. states in which diving fatalities occurred.
(100% response)

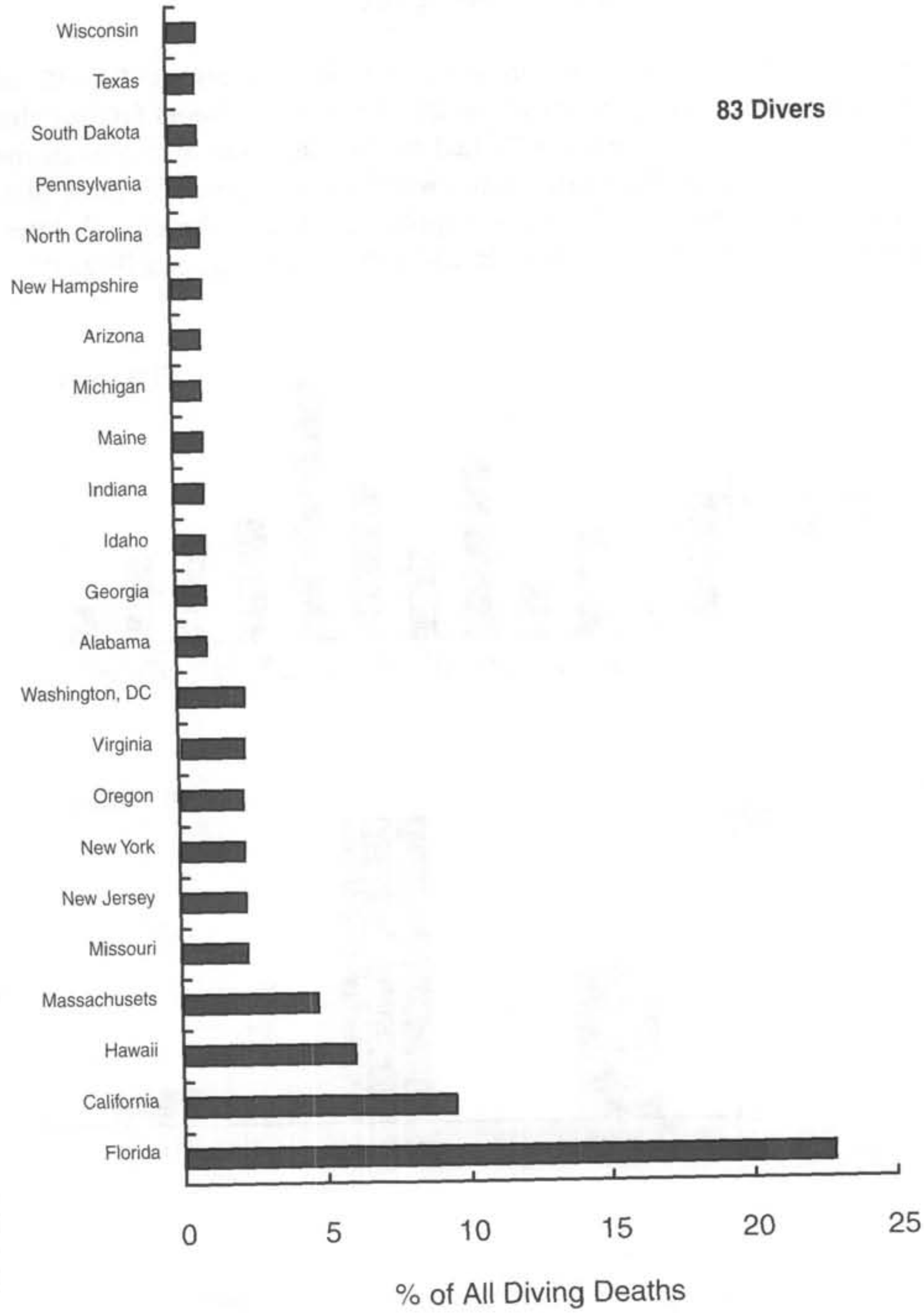


Figure 79 shows that 77% of diving fatalities occurred in salt water and 22% in fresh water. The day-boat was the most common dive platform at 69% while the remaining fatalities began their dives from shore (Fig. 80). Recreation was the reason for diving in half the fatalities (Fig. 81). The category "Specialty" included cave, ice, mixed gas, deep, and wreck penetration dives. Eighty-five percent of the divers breathed air although 13% used heliox or trimix (Fig. 82). Heliox made up only 1% of diving injuries (Fig. 36). Wetsuits (63%) and drysuits (22%) were the most common thermal protection (Fig. 83).

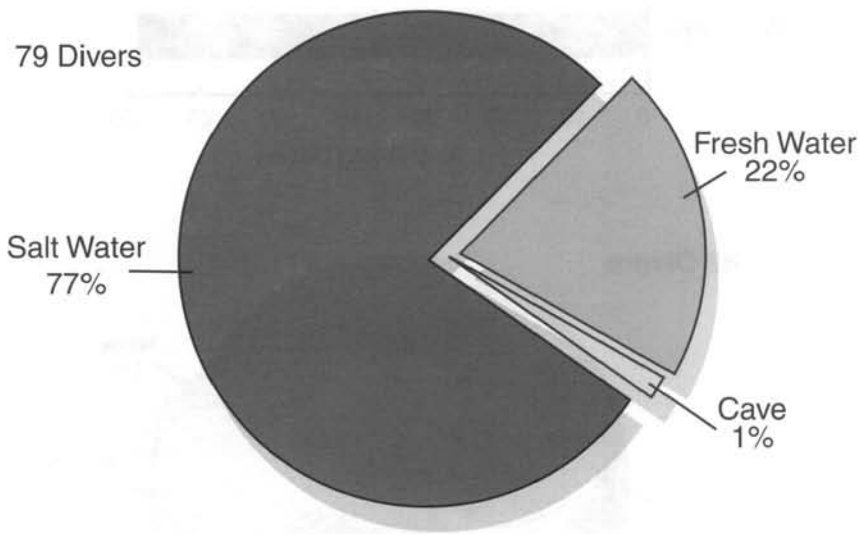


Figure 79. Site where diving fatalities occurred. (95% response)

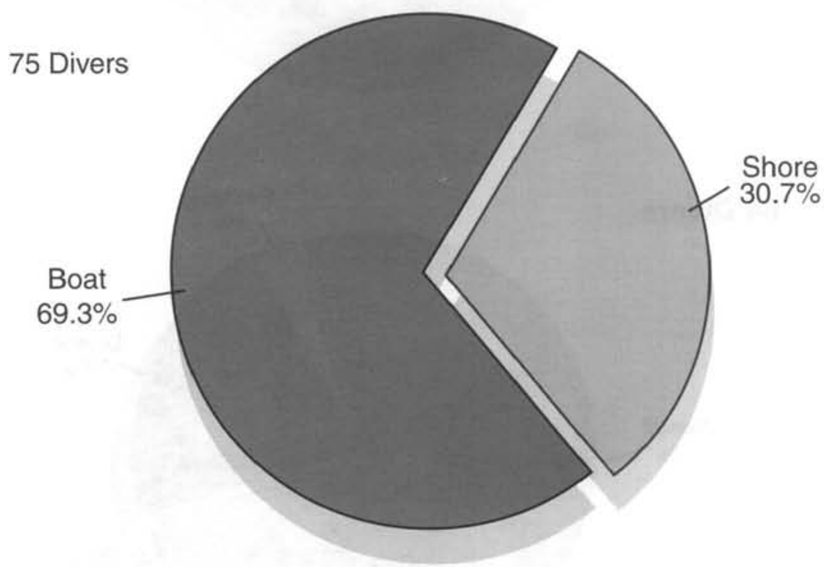


Figure 80. Dive platform from which fatalities occurred. (90% response)

Figure 81. Reason for diving.
(100% response)

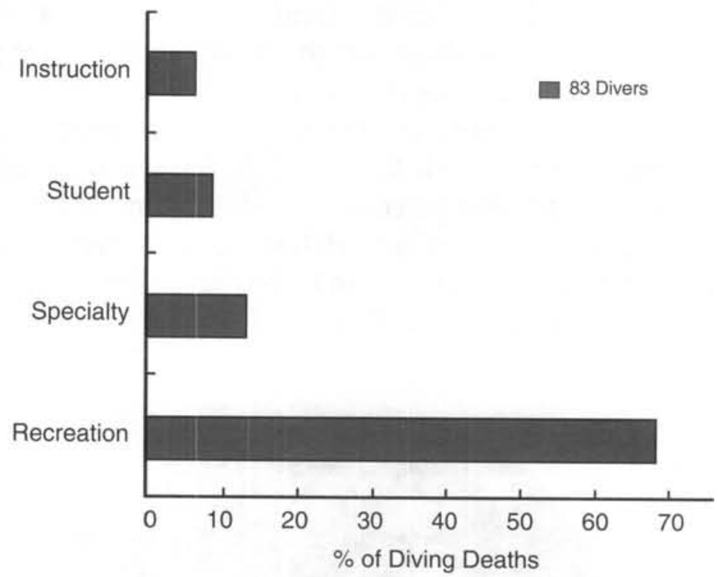


Figure 82. Breathing gas used by diving fatalities.
(99% response)

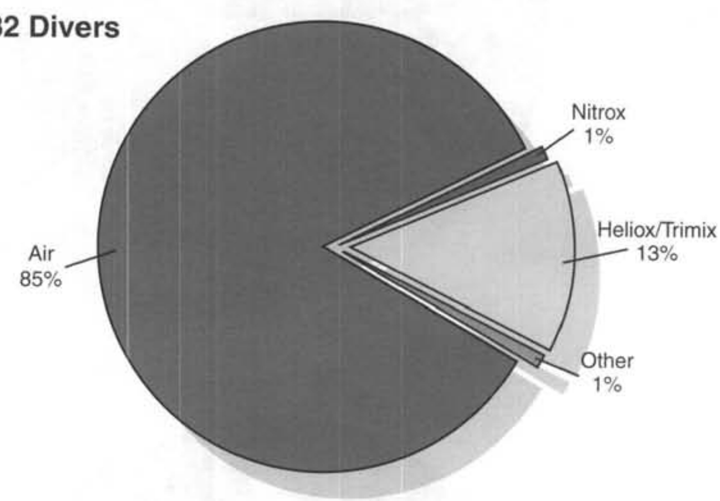
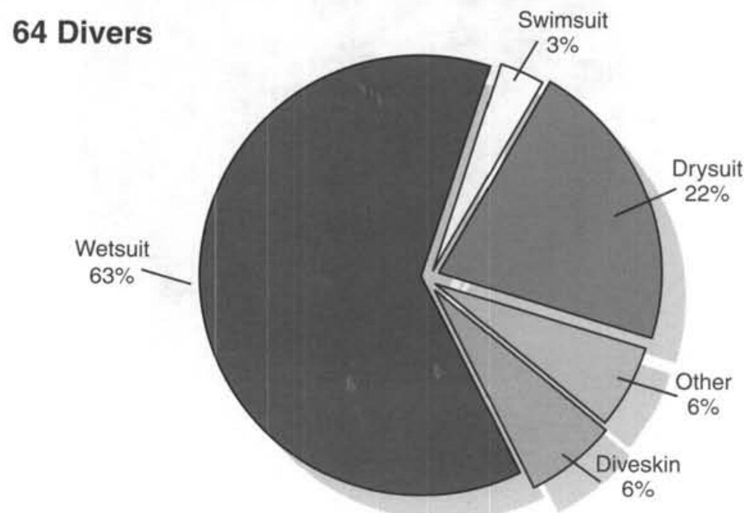


Figure 83. Thermal protection used by diving fatalities.
(77% response)



More than 70% of fatalities occurred on the first dive, and none of the 62 divers for whom data were available made more than three dives (Fig. 84). Diving injuries, in contrast, were distributed over a wide range of diving activity (Fig. 39). Figure 85 shows that the most common maximum diving depths for fatalities were 60-90 fsw, and 80% of fatalities occurred within the recreational diving limit of 130 fsw. About 14% were deeper than 180 fsw.

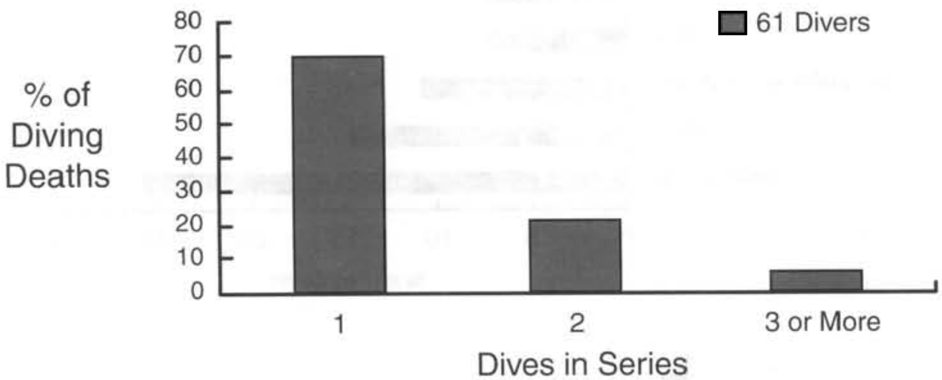


Figure 84. Number of dives made by diving fatalities.
(73% response)

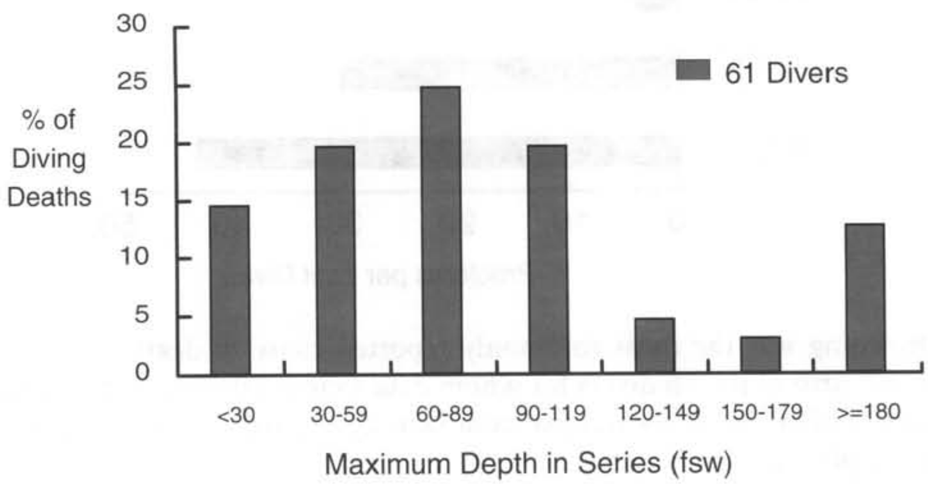


Figure 85. Maximum depth in dive series by diving fatalities.
(73% response)

The most common equipment problems were with the depth gauge and buoyancy compensator (Fig. 86). Rapid ascent and buoyancy problems were reported in the case of 30% and 43%, respectively, of 26 divers for whom data were available (Fig. 87).

Figure 86. Equipment problems by diving fatalities. (77% response)

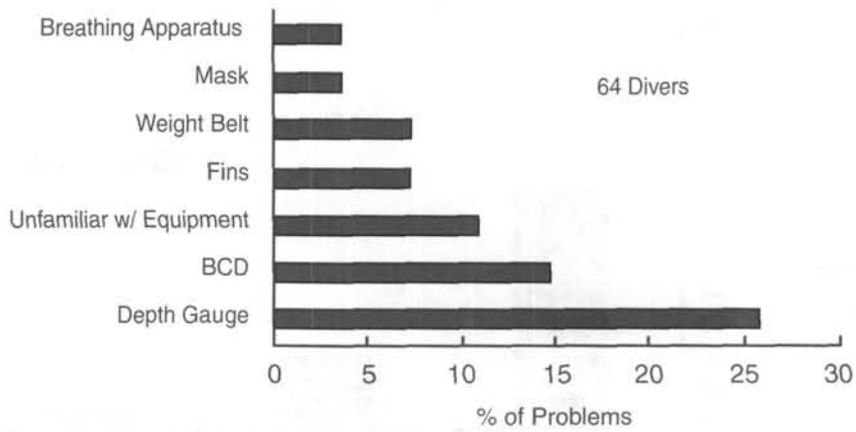
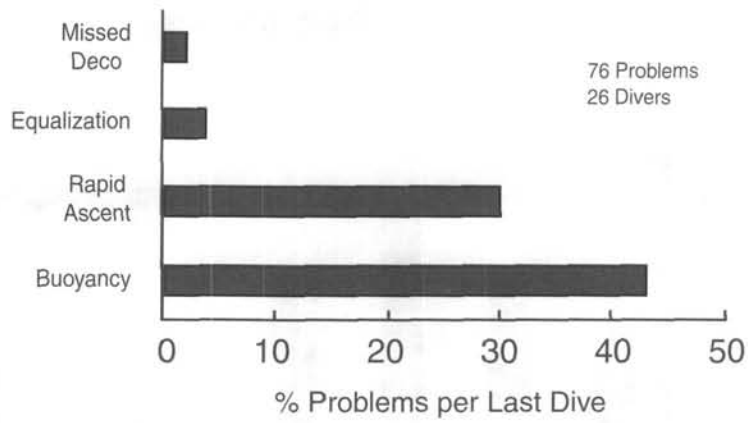
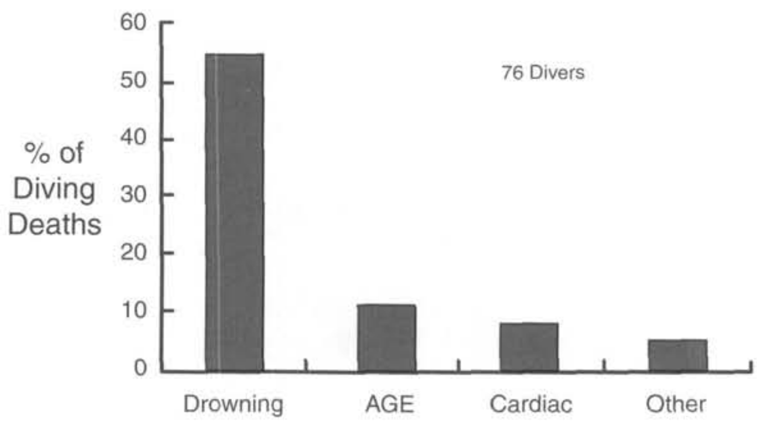


Figure 87. Problems during dive associated with fatalities. (31% response)



Drowning was the most commonly reported cause of death (Fig. 88). One-fourth of the 76 divers for whom data were available had heart disease. "Other" includes trauma from boat collisions, pulmonary edema and asphyxia.

Figure 88. Cause of Death. (91% response)



4.4 Case Reports

While diving injuries sometimes occur when everything was done correctly, diving fatalities generally have one or more significant causes. These can include health issues, equipment problems, inadequate training and deep diving.

Case 1. An Unqualified Cave Diver (98-1)

A 42-year-old male with 40 lifetime dives and no formal cave diving training became lost in a side passage of a cave he entered while diving with another diver. His situation was complicated by a free-flowing regulator, according to his dive buddy. The dive buddy was also low on air and, after the two divers became separated, he went to the surface to get help. Rescue divers found the deceased diver without air in his tank and brought him to the surface where resuscitation efforts were unsuccessful. The immediate cause of death was listed as drowning due to insufficient air, entrapment in a cave and scuba diving. Possible contributing conditions included: alcohol use, benzodiazepine use, antihistamine use, tobacco use and panic. A gastrointestinal stromal tumor was a significant incidental diagnosis.

Case 1.
An Unqualified
Cave Diver

Case 2. A Deep Air Dive by a Diver with a Terminal Illness (98-18)

A 52-year-old experienced, male diver made a "bounce" dive to 175 fsw on air for seven minutes followed by a very rapid ascent to the surface. He became incapacitated on the surface and was pronounced dead at a local medical facility. The diver had descended to a wreck without a buddy. He had been ill for two days prior to the dive and was visibly ill during the boat ride out to the dive site. The diver knew that he had a terminal illness, and this case may represent either a suicide or a diver's attempt to get one last dive in. The immediate cause of death was listed as air embolism due to rapid ascent and scuba diving. Possible contributing conditions included: hepatocellular carcinoma, above the knee amputation, severe coronary atherosclerosis, cirrhosis, esophageal varices and subcutaneous emphysema.

Case 2.
A Deep Air Dive
by a Diver with a
Terminal Illness

Case 3. A Diver with Diabetes (98-32)

A 45-year-old male diver with open-water certification had an eight-year history of insulin-requiring diabetes. He had not made a dive during the previous year until this set of dives. While diving the previous day, the decedent remarked that he felt poorly and planned on increasing his insulin dose for the following day's dives. During his final dive, the decedent became separated from the group and was found unconscious on the bottom just a few minutes later, with his regulator out of his mouth.

Case 3.
A Diver with
Diabetes

The autopsy lists the cause of death as an air embolism based on the finding of intravascular gas, but the diver was dead when found, and the dive profile was incompatible with AGE. It is possible that the added insulin played a role in this mishap. A carboxy-hemoglobin of 15% was also abnormally high, especially in a non-smoker like this diver although the diver's air was tested and found to be good. The immediate cause of death was listed as drowning due to presumed hypoglycemia from diabetes mellitus. Possible contributing conditions included: scuba diving, left ventricular hypertrophy and carbon monoxide exposure (COHb = 15 %).

Case 4. An Untrained Diver with a Stroke

Case 4. An Untrained Diver with a Stroke (98-34)

A 26-year-old male had no documented formal dive training and was using scuba gear in order to go spearfishing. He became separated from his buddy and was next seen calling for help on the surface before he disappeared. His body was recovered 30 minutes later. The autopsy disclosed the cause of death, which appears to be unrelated to diving, as a cerebrovascular accident due to a cerebral aneurysm. Possible contributing conditions included: scuba diving and cannabinoids.

Case 5. A Seizure on the Wrong Mix

Case 5. A Seizure on the Wrong Mix at 250 fsw (98-17)

A 35-year-old male diver under instruction for deep trimix diving made a dive to 253 fsw with an instructor and two other divers. This was his first dive below 200 fsw. The student had difficulty controlling his buoyancy and was struggling to stay off the bottom. The divers made multiple excursions between 250 and 180 fsw before the decedent exhausted his bottom mix and switched to a travel gas that contained 40% oxygen at a partial pressure of 2.6-3.4 atm. He was witnessed to have a seizure shortly thereafter. One of the four divers made it back to the surface, the body of a second member of the dive group was recovered one month later, and the bodies of the remaining two divers, including that of this diver, were never recovered. The immediate cause of death was listed as drowning due to seizure and scuba diving.

Case 6. Unconsciousness and Drowning

Case 6. Unconsciousness and Drowning (98-27)

A 47-year-old experienced diver became separated from her dive buddy during descent down an anchor line. She was later found unconscious on the bottom. The autopsy listed drowning as the cause of death due to acute myocardial infarction and severe coronary atherosclerosis. Possible contributing conditions included scuba diving and obesity. Significant incidental diagnoses were papillary thyroid carcinoma and lung chemodectoma.

Case 7. Unconsciousness during a Trimix Dive (98-39)

A 41-year-old male with extensive diving experience was making deep trimix dives to explore a wreck with a group of divers. He made an uneventful first dive to 180 fsw and a second dive was to 170 fsw. During the second dive, the decedent became entangled, appeared to be breathing hard and lost consciousness. His dive buddies, faced with the difficult situation of having an unconscious diver on the bottom, inflated the decedent's buoyancy compensator and sent him directly to the surface. He received CPR and was transferred to a local emergency room where the he was pronounced dead. The immediate cause of death was listed as air embolism due to rapid ascent, cardiac dysrhythmia, and coronary atherosclerosis. Possible contributing conditions included scuba diving, pulmonary barotrauma and closed head trauma.

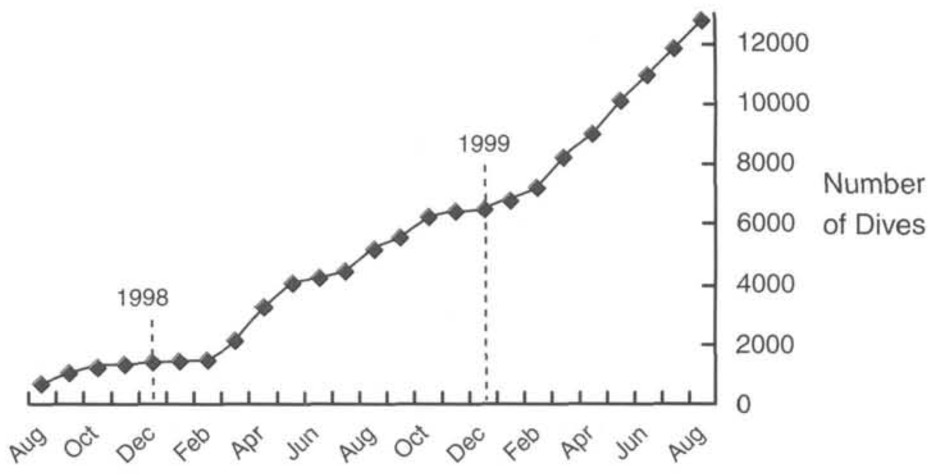
Case 7. Unconsciousness during a Trimix Dive

Project Dive Exploration

Information about diving injuries and fatalities helps to identify contributing factors, but it does not address the underlying risks. To understand risk, one must know about safe dives as well, and as DCI risk is determined by depth-time exposure, knowledge of the dive profiles is also necessary.

The possibility of acquiring this information arose in the late 1980s when the dive computer manufacturers Suunto and Orca introduced relatively inexpensive instruments that could record depth-time profiles. DAN began working with Suunto and Orca in 1992, but successful data collection did not start until mid-1997 in an effort called Project Dive Exploration. In its initial two years (August 1997 to September 1999), Project Dive Exploration (PDE) collected 12,849 dives by 1,234 divers (329 females, 905 males) as illustrated in Fig. 89.

Figure 89. PDE data collection progress.



Project Dive Exploration was approved by the Institutional Review Board of Duke University Medical Center, which reviews all studies involving human subjects, and divers who volunteered their data gave Informed Consent as required by the National Institutes of Health (NIH). DAN trained several hundred volunteers to collect data as Field Research Coordinators (FRCs). About 20% of the trained FRCs actively collected data. Twenty self-supported FRCs collected about one-quarter of the total dives. Three commercial diving operations were equipped for data collection and established as Data Collection Centers (DCCs). A dozen FRCs associated with DCCs collected more than half the dives.

The remaining quarter were collected by six DAN staff. The Nekton Pilot liveaboard dive boat, one of the Data Collection Centers, deserves particular recognition for maintaining a trained crew of FRCs who collected more than 3,700 dives. A full listing of FRCs and DCCs may be found under Acknowledgements. (pg. 5)

Project Dive Exploration has been possible because of the strong support of four dive computer manufacturers: Cochran Consulting (Richardson, Texas), Orca (no longer available), Suunto (Finland), and Uwatec (Zurich, Switzerland). These companies donated their instruments to DAN, modified their software to work with DAN software, and cooperated with DAN during development of the data collection methodology.

Data collection continues with efforts to simplify the process and make more PDE-compatible dive computers available to the diving public. Information about Project Dive Exploration is available from the DAN website at www.DiversAlertNetwork.org. A descriptive summary of observations to date appears below.

Data collection continues with efforts to simplify the process and make more PDE-compatible dive computers available to the diving public.

5.1 Limitations

Data collection was conducted by relatively few FRCs and few diving operations. The data collection sites were not necessarily representative of all dive locations and conditions. Had more dive computers been available, more FRCs could have collected data at other sites. The population sample of divers who contributed data were a select group (they volunteered, and almost all used dive computers). They were not necessarily representative of the recreational diving community as a whole.

During the initial phases of data collection, software problems and changes to procedures or forms prevented timely completion of some data fields. Thus, not all the data described below are based on the total number of dive profiles that were collected. The completeness of each field is indicated in the text or the figure captions.

5.2 Characteristics of PDE Divers

A total of 1,234 divers contributed 1,668 dive series during two years of data collection. (A dive series is defined as a group of dives preceded by 48 hours without diving and followed by 48 hours without diving or altitude exposure.) Some divers volunteered multiple times. Multiple participation was indicated by database entries to reflect changes in age, certification, experience and health status.

The distribution of PDE divers across age and gender is shown in Fig. 90. Divers in the 30-39 age range were the most common, and relatively few divers were under 19 or over 50. Females made up 26% of PDE volunteers. The PDE age and gender distribution was similar to that of divers injured in 1998 (Fig. 23), but PDE divers were younger than diving fatalities (Fig. 69).

Figure 90. Age and gender of PDE divers.
(99% response)

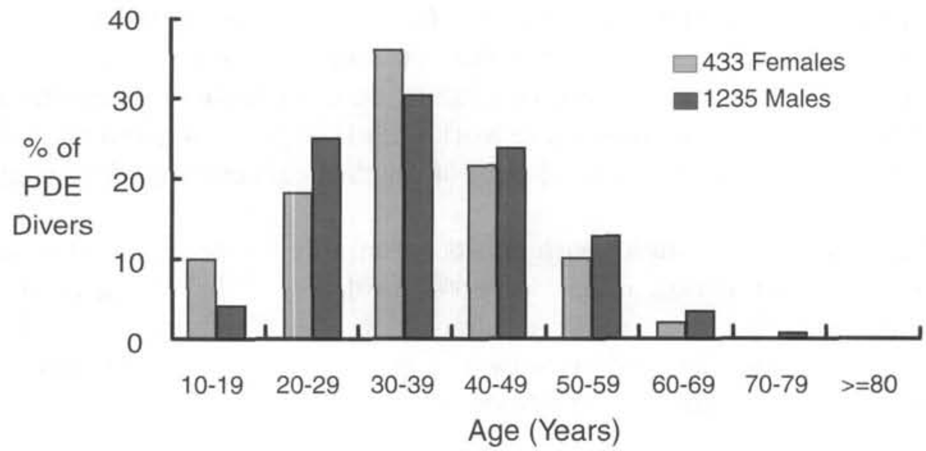
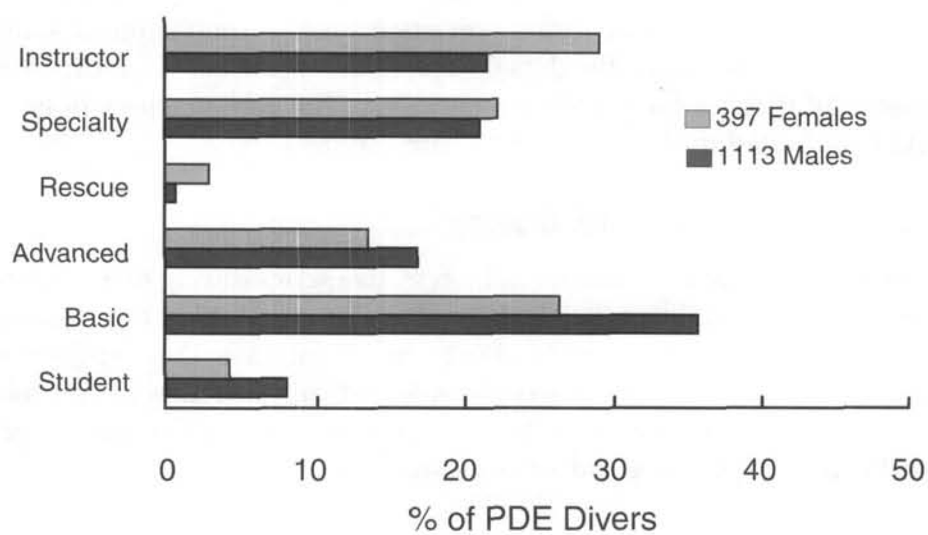


Figure 91 shows that a smaller proportion of PDE divers had Basic or Advanced certification (45%) than did injured divers (80%, see Fig. 24), and larger proportions of PDE divers were Instructors or Specialty divers (40%) than were injured divers (10%). The proportion of female Instructors was greater for PDE while a greater fraction of injured female divers held Basic certification. In general, PDE divers had more training than did diving fatalities (Fig. 70).

Figure 91. Certification of PDE divers by gender.
(91% response)



One-fifth of PDE divers had been diving for one year or less (Fig. 92) while 30% of injured females had been diving for a year or less (Fig. 25). The proportion of fatalities who were within one year of initial certification was 40% for males and 60% for females (Fig. 71). A greater fraction of PDE divers had been trained six or more years earlier than divers who were injured or died.

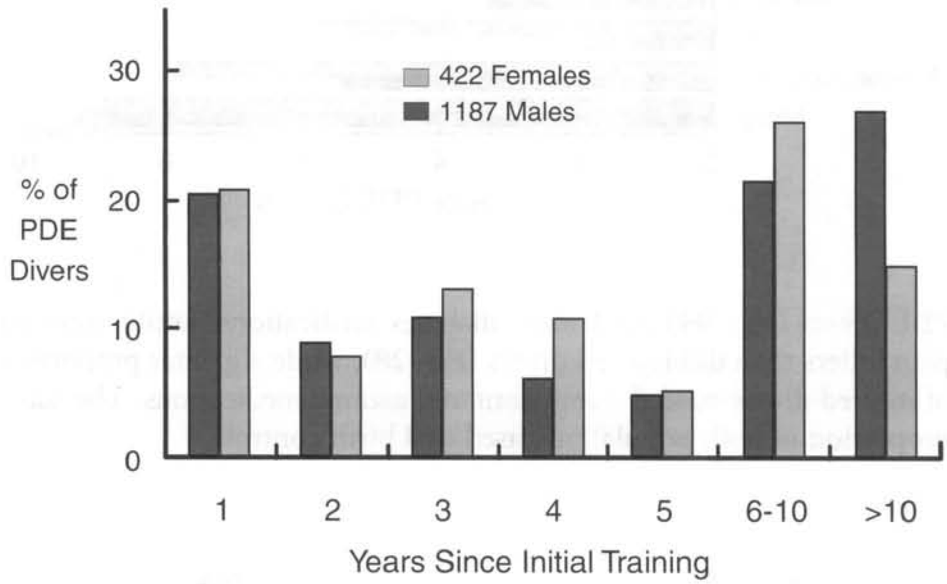
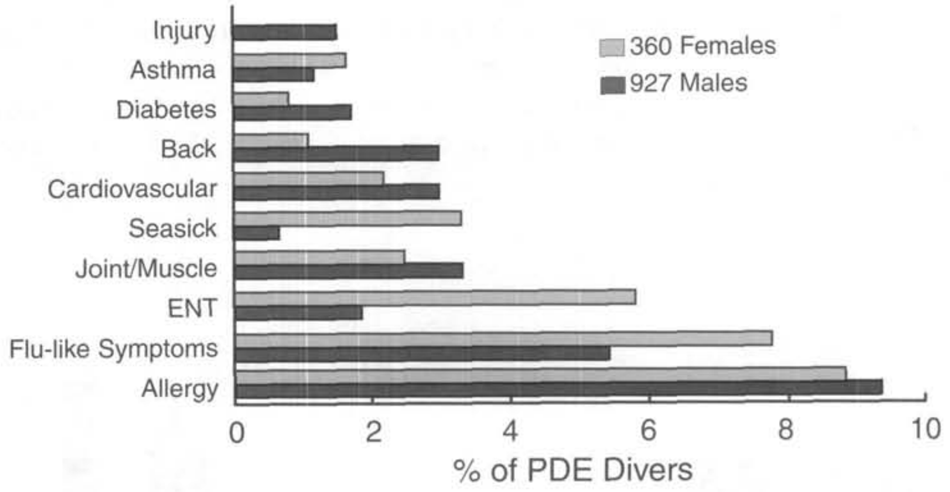


Figure 92. Years since initial training for PDE divers by gender.
(97% response)

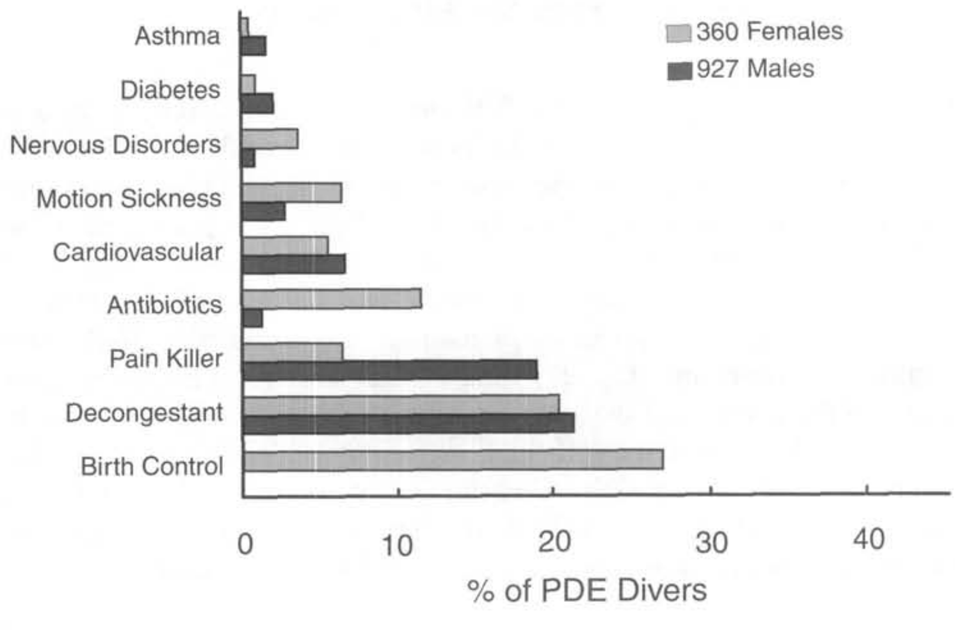
Pre-existing health problems for PDE divers were expressed as the percentage of dive series for which divers reported a health issue (Fig. 93). At nearly 10%, allergy was the most common problem for males and females. Females were more likely to report flu-like symptoms, ear, nose and throat trouble, or seasickness, while males predominated with injuries and cardiovascular, joint/muscle and back problems. Injured divers had higher proportions of asthma, cardiovascular, back, and joint/muscle problems (Fig. 27) than PDE divers, but a higher proportion of PDE divers had diabetes because a recent DAN diabetes study monitored diving activity with PDE methodology. Two percent of PDE divers reported having asthma as did 2% of injured male and 6% of injured female divers. No male diving fatalities were reported to have asthma, but asthma was reported in 25% of 16 female fatalities.

Figure 93. Current health problems PDE divers by gender. (77% response)



PDE divers (Fig. 94) used more diabetes medications, antibiotics and pain killers than did injured divers (Fig. 28), while a greater proportion of injured divers used decongestant and asthma medications. The same proportion of both populations used oral birth control.

Figure 94. Medications used by PDE divers by gender. (77% response)



5.3 Dives by PDE Divers

The months of peak diving activity for PDE divers (Fig. 95) were spring through summer, similar to those of injured divers (Fig. 29). PDE divers were more active in the morning and evening (Fig. 96) while diving injuries (Fig. 30) and fatalities (Fig. 75) occurred most often in the afternoon (Fig. 30).

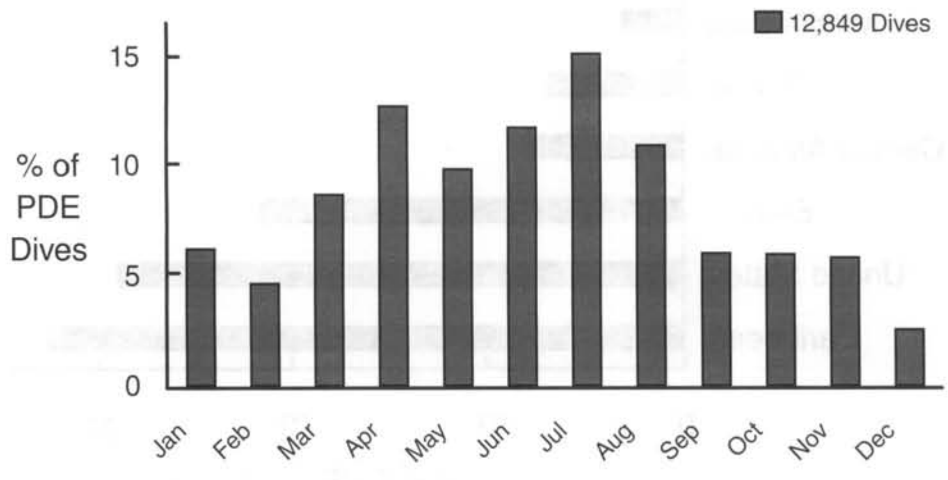


Figure 95. Month of dives by PDE divers. Divers who participated multiple times made 28% of the dives series. (100% response)

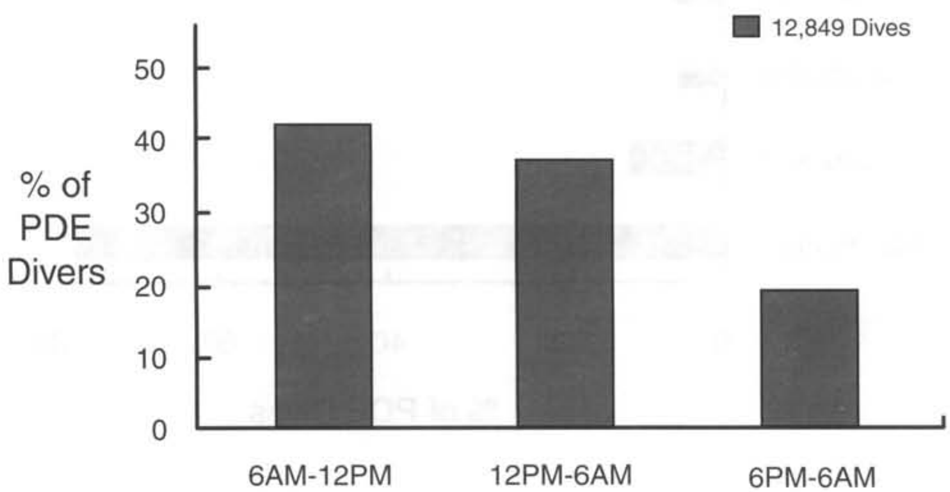


Figure 96. Time of day of dives on which PDE dives occurred. (100% response)

Most PDE dives (70%) were done in United States, Caribbean and Central American waters, but several active FRCs in England and Austria contributed 21% of the dives (Fig. 97). Nearly 80% of PDE divers were diving for recreation as were injured divers (Fig. 34) with similar proportions diving for other purposes (Fig. 98).

Figure 97. World region in which PDE dives occurred. (67% response)

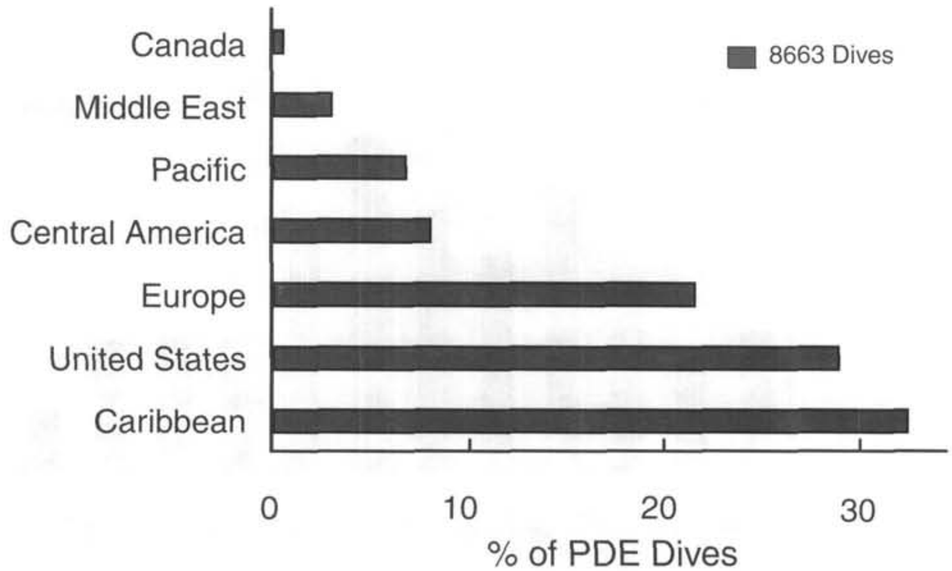
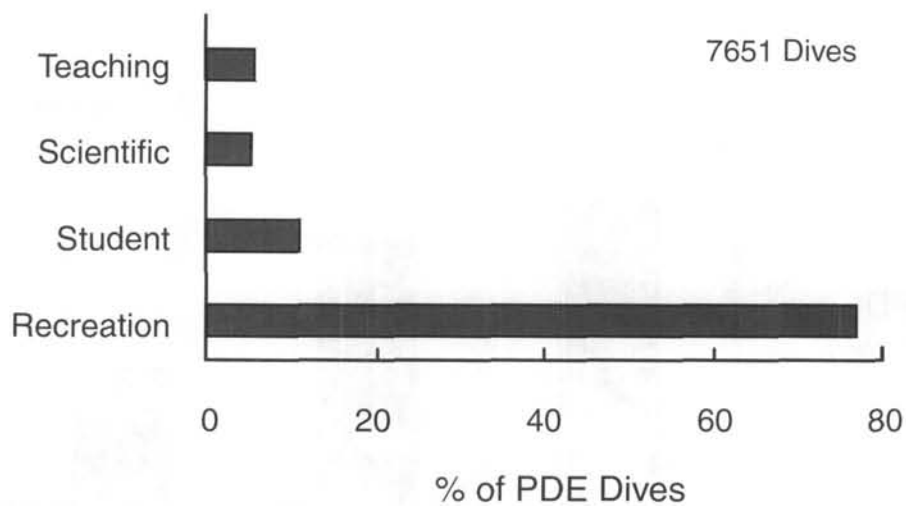


Figure 98. Reason for PDE diving. (60% response)



Half the PDE dives were collected from liveaboard dive boats, 29% from day boats, and 19% from the shore (Fig. 99). No fatalities occurred on liveaboard dive boats (Fig. 80).

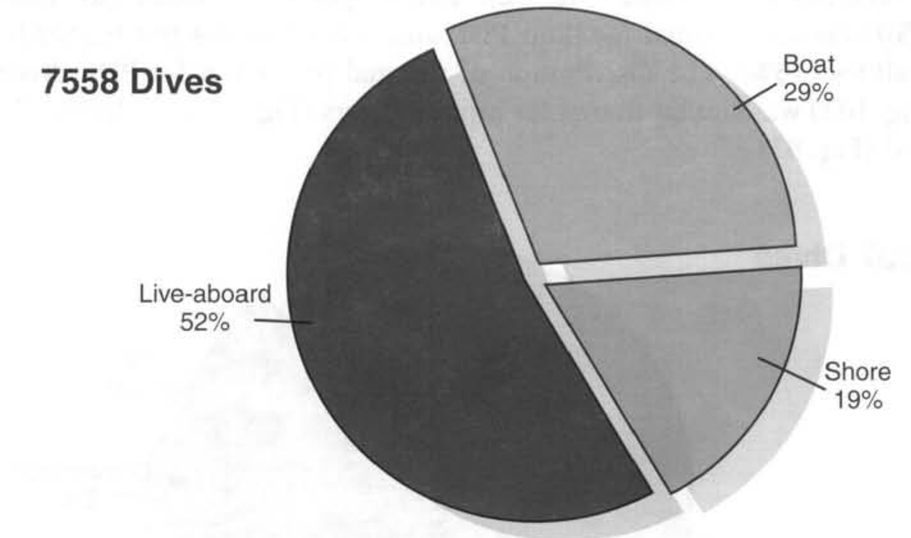


Figure 99. Dive platform for PDE dives. (59% response)

Salt water was the predominant location of PDE dives (Fig. 100) as for diving injuries (Fig. 33), and 19% of PDE dives were made in fresh water, but only 10% of injuries occurred in fresh water.

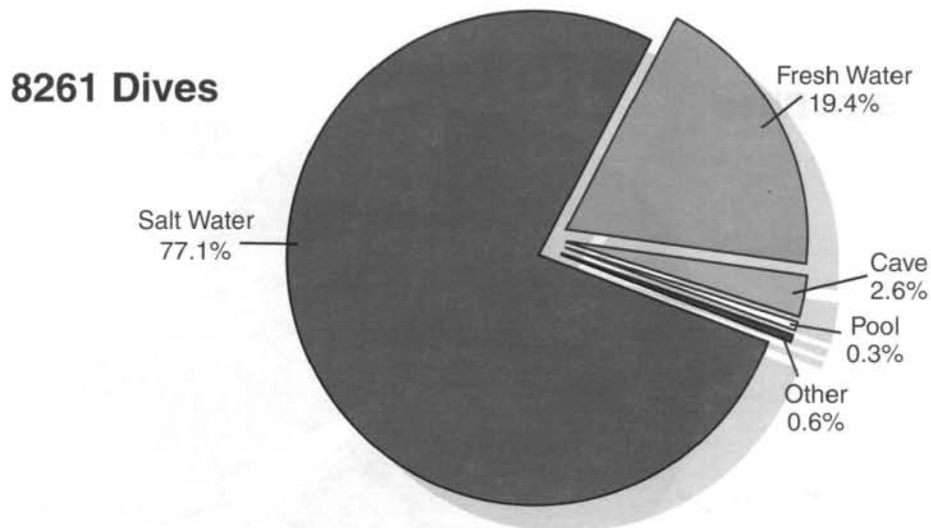


Figure 100. Sites where PDE dives occurred. (64% response)

All of the responding PDE divers (58% of the total) used open-circuit scuba for their dives. Figure 101 shows that while air was the predominant breathing gas (83.3%), the proportion of PDE divers who used nitrox (14%) was double that for injured divers (6.7%, Fig. 36). Only 1% of fatalities used nitrox (Fig. 82). The proportion of other gas mixes (3%) was about equal for both PDE and injured divers but higher for fatalities (13%). The distribution of thermal protection for PDE divers (Fig. 102) was similar to that for injured divers (Fig. 37) and divers who died (Fig. 83).

Figure 101. Breathing gas used by PDE divers. (58% response)

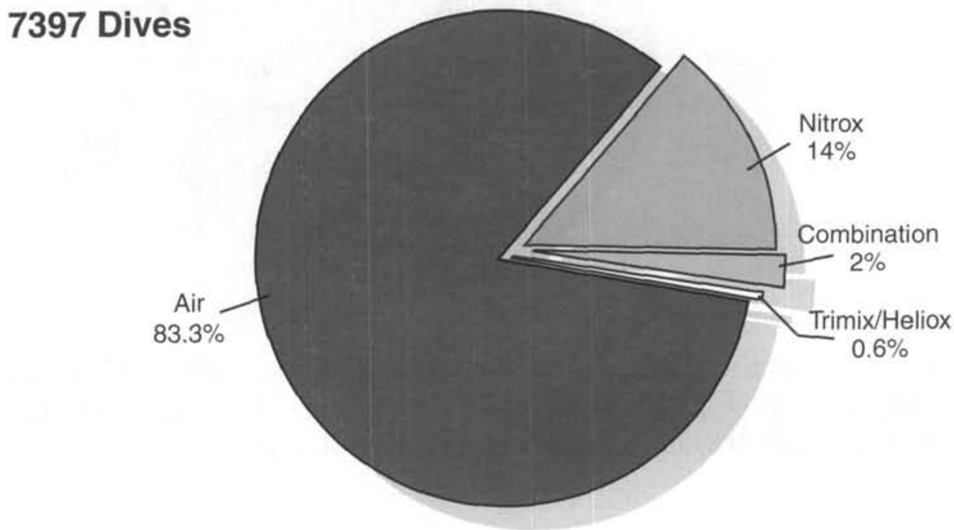
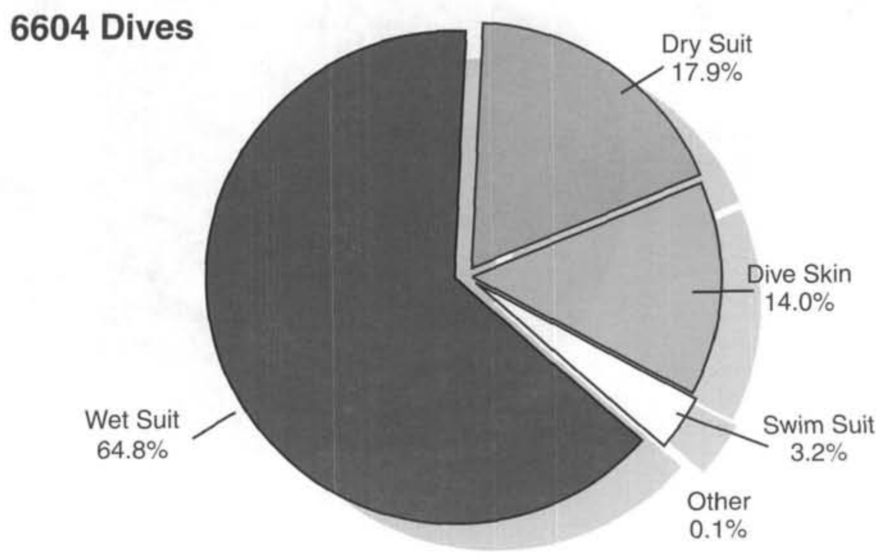


Figure 102. Thermal protection used by PDE divers. (51% response)



PDE divers had fewer one and two-day dive series (Fig. 103) than injured divers (Fig. 38) and had more dive series of six days or longer. PDE divers also had fewer single-dive series (Fig. 104) than injured divers (Fig. 39), with a quarter of the PDE series involving two dives and 30-40% involving 11 or more dives. Diving injuries tended to occur in shorter dive series. Seventy percent of diving fatalities occurred on the first dive (Fig. 84).

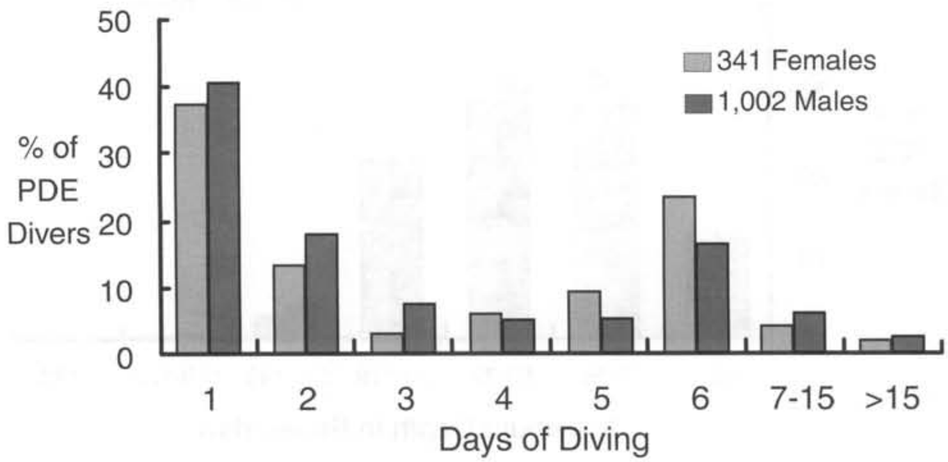


Figure 103.
Days of diving in dive series by PDE divers by gender. A dive series is 48 hours without diving followed by 48 hours without diving or altitude exposure.
(81% response)

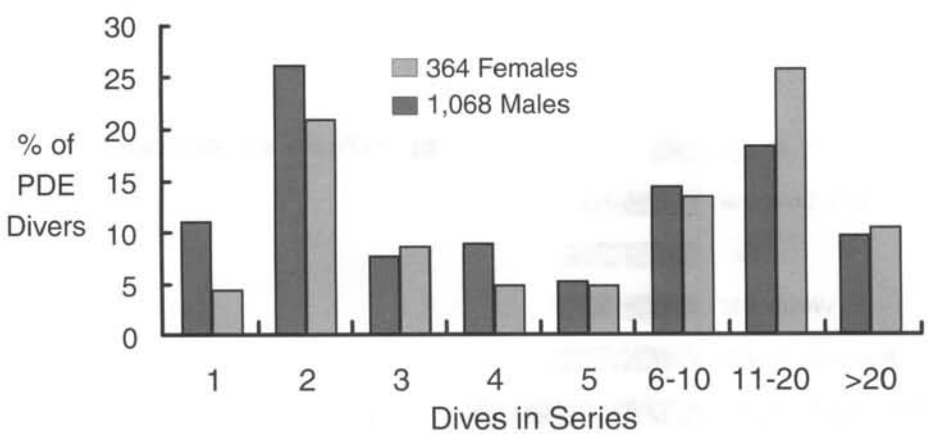
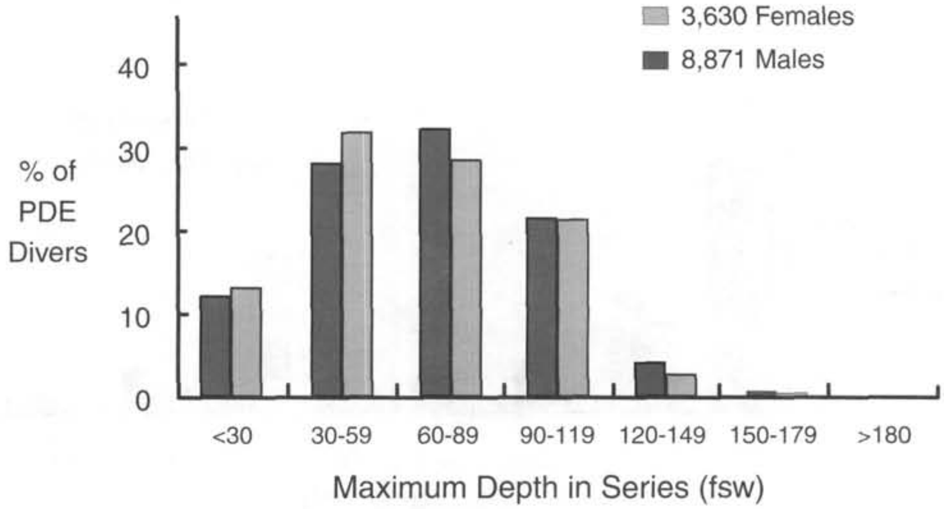


Figure 104.
Number of dives in dive series by PDE divers by gender.
(86% response)

Figure 105 shows that PDE divers did not dive as deep as did injured divers (Fig. 40). About 70% of the maximum depths for PDE dives were no greater than 90 fsw while this was true for only about 50% of the injured divers. Almost all the PDE divers used dive computers to plan their dives, while only 61% of injured divers used dive computers (Fig. 42).

Figure 105. Maximum depth in dive series by PDE divers by gender. (97% response)



In 1% of all PDE dives, the mask posed the most common equipment problem (Fig. 106). In 0.4% of all dives, divers experienced breathing apparatus difficulties, while trouble with buoyancy compensators, weight belts, fins, and dive computers occurred in about 0.2% of dives.

Figure 106. Problems with equipment during PDE dives.

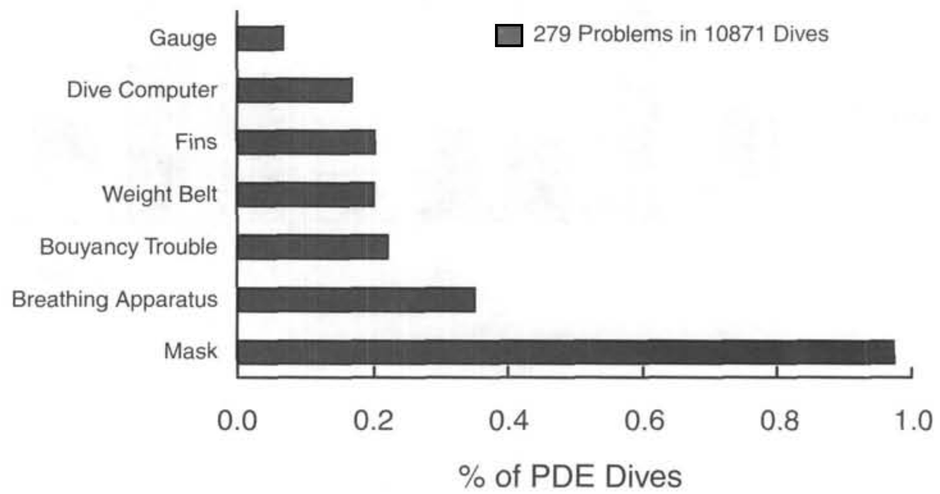


Figure 107 shows the problems per dive reported by PDE divers. At 5% of reported dives, equalization of the ears was the most common diving problem for PDE divers. The incidences of missed decompression (0.3%), out-of-air (0.3%), and rapid ascent (1%) were lower than missed decompression (15%), out-of-air (5%), and rapid ascent (23%) for injured divers (Fig. 43). At 40%, rapid ascent was even more common in diving fatalities (Fig. 87).

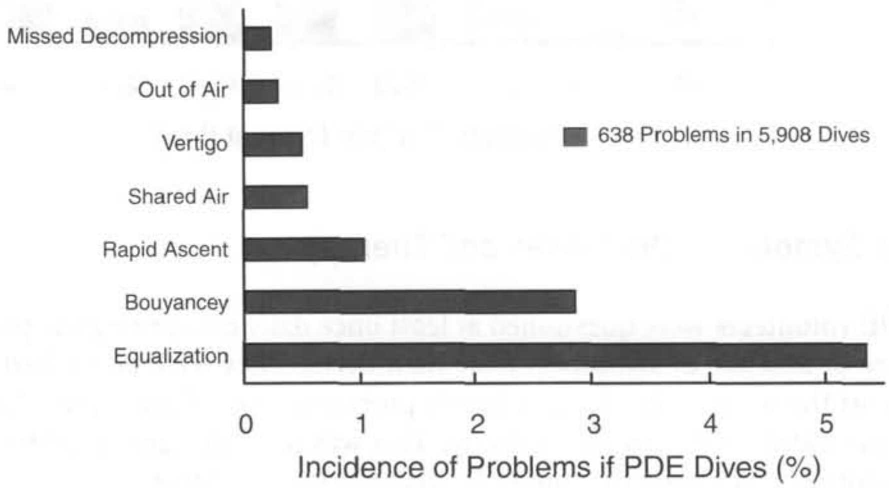


Figure 107. Incidence of problems in PDE dives.

Of the 1,668 PDE dive series, 721 divers provided information about altitude exposure after diving (Fig. 108). Sixty-eight percent of these were not exposed to altitude, 23% flew in commercial aircraft, 8% were exposed to mountain altitudes, and one diver flew in an unpressurized aircraft. Figure 109 compares the preflight surface intervals of PDE and injured divers. In general, PDE divers observed longer surface intervals than did injured divers.

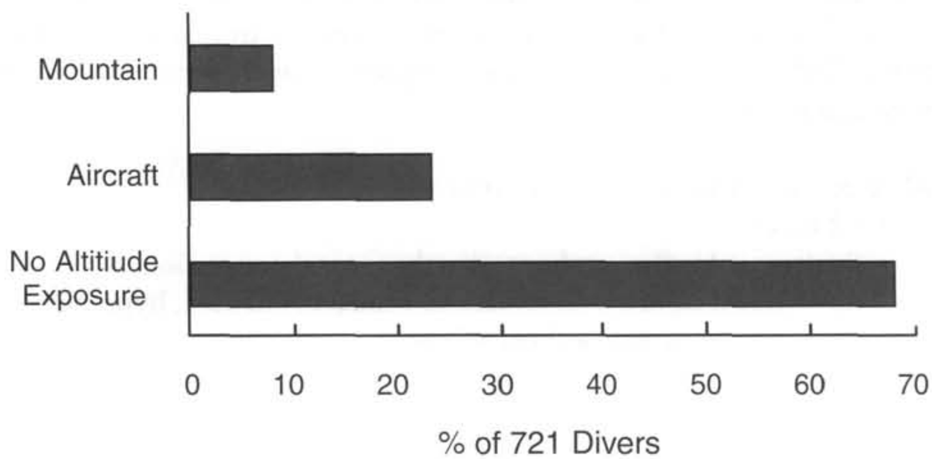
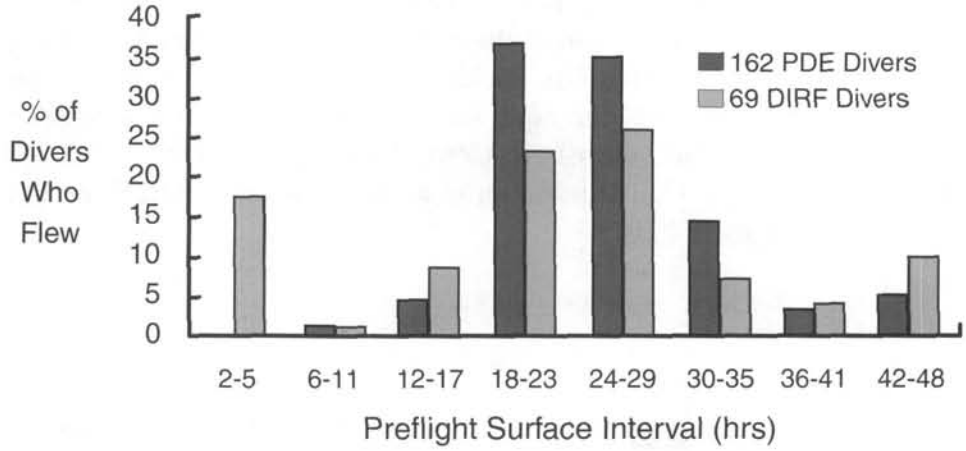


Figure 108. Altitude exposure after diving.
(43.5% response)

Figure 109. Surface intervals before flying after diving.



5.4 Symptoms, Diagnoses and Therapy

PDE volunteers were questioned at least once daily concerning the presence or absence of symptoms after their dives. They were also asked to report the occurrence of other health problems, even if they were clearly unrelated to the diving exposure. This was to minimize the underreporting of symptoms that might be decompression illness.

When a dive series ended, the Field Research Coordinator (FRC) gave the diver a 48-Hour Report form to be completed 48 hours after the last dive or altitude exposure. The report was returned to the FRC or to DAN. The 48-Hour Report asked the diver to deny or confirm the occurrence of symptoms, to report recompression therapy and to report details concerning altitude exposure. To date, 43.5% of PDE divers have submitted such reports.

Symptom classification attempted to distinguish between symptoms due to illness or injury and those that had no identifiable cause but were compatible with DCS although not recompressed. In two years of PDE data collection, 76 divers reported symptoms which were classified as indicated below.

(a) "Not DCS" (due to illness or injury)
- 62 divers
- Bruises, colds/flu, sunburn, diarrhea, nasal congestion, mechanical injury, inflammation, headache, nausea, hypothermia, ear squeeze, marine animal injury.

(b) "Ambiguous" (possible DCS but not recompressed)
- 11 divers
- Diver 1: pain in left shoulder and right wrist.
- Diver 2: left shoulder pain and tingling in left hand.
- Diver 3: left shoulder pain and forearm weakness.
- Diver 4: mild left ankle pain and itching around neck.
- Diver 5: severe pain in left shoulder; moderate pain and numbness of left elbow.
- Diver 6: limb pain.
- Diver 7: mild tingling of left hand and fingers.
- Diver 8: pain in both elbows.
- Diver 9: moderate pain in left wrist.
- Diver 10: skin changes and joint pain.
- Diver 11: pain in left arm and numbness in elbow.

(c) "Recompressed"
- Four divers were diagnosed as DCS by the treating physician and recompressed. These cases are described below with dive profiles shown in Figs. 110-113.

Case 1. Pain and Neurological Symptoms while Flying After Diving.

A 43-year old female diver with 10 years of diving experience made 10 dives in four days to depths as deep as 140 fsw (Fig. 110). Twenty-six hours after her last dive, she flew home by commercial air. During the flight, she developed right shoulder pain and tingling of her left forearm and hand. She was treated on Table 6 the next day with complete resolution of her symptoms.

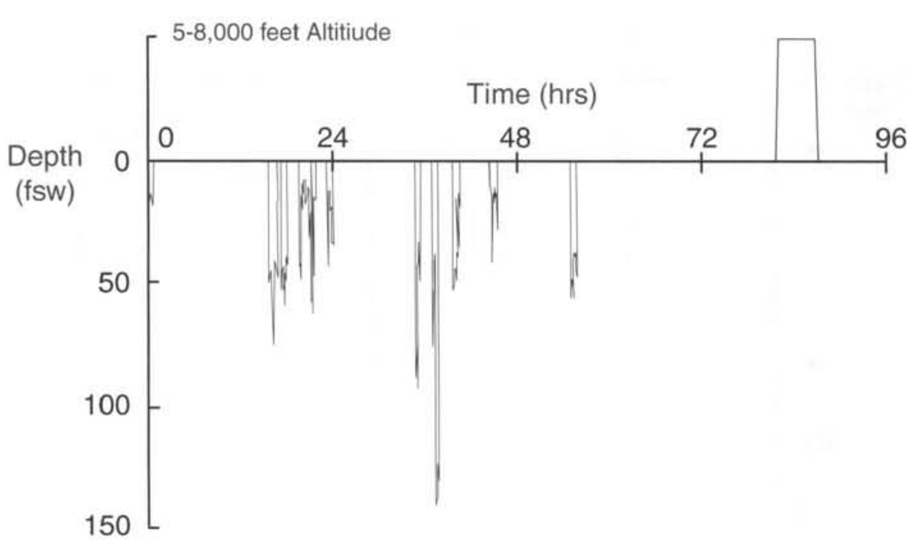
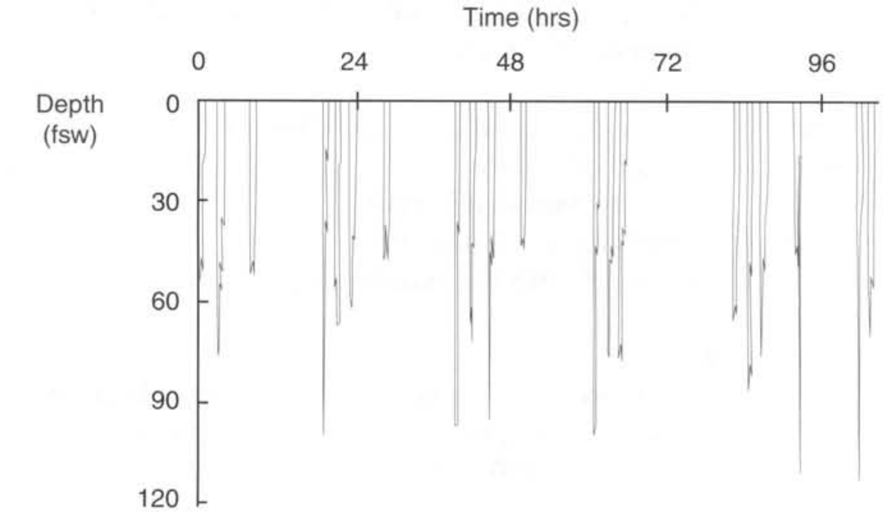


Figure 110. Case 1. Pain and neurological symptoms with onset during flying after diving.

Case 2. Lymphatic Symptoms After 20 Dives in Six Days

A 43-year old female diver with extensive experience made 20 dives in six days to depths as deep as 110 fsw (Fig. 111). Shortly after Dive 20, she developed skin changes and swelling in an unspecified location. Her symptoms were relieved by recompression.

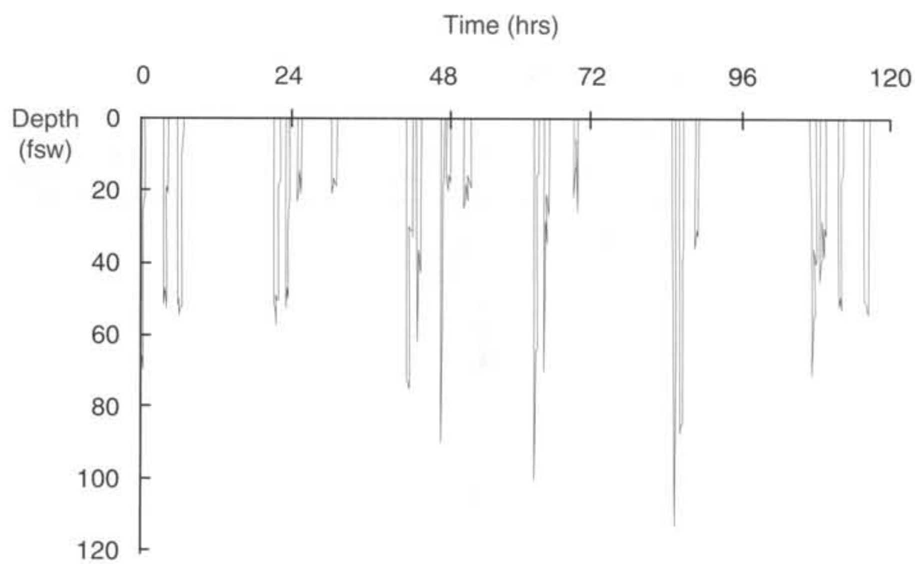
Figure 111. Case 2. Lymphatic Symptoms After 20 Dives in Six Days with onset after the last dive.



Case 3. Shoulder Pain During 20 Dives in Six Days

A 30-year old female diver with three years of diving experience made 20 dives in five days to depths as deep as 110 fsw (Fig. 112). On Day 5, she developed pain in her left shoulder and back but continued diving on Day 6. Three days after her last dive, she was recompressed on a Table 6, resulting in a decrease of pain from Grade 8 to Grade 3 on a scale of 0-10. She was treated the next day for 90 minutes at 45 fsw with 100% oxygen but had no further relief. Her symptoms resolved completely after several days treatment with NSAIDs.

Figure 112. Case 3. Shoulder Pain During 20 Dives in Six Days.



Case 4. Vestibular Symptoms After Six Trimix Dives

A 54-year old male diver with 30 years of diving experience made six trimix dives in six days on the USS Monitor (Fig. 113). Only the last two profiles were recorded by dive computer. The last dive was to a depth of 220 fsw. Thirty-eight minutes after the dive, the diver developed vertigo and vomited twice. A neurological examination by a Diving Medical Officer on a nearby Navy vessel revealed no evidence of otic barotrauma, and abnormalities in heel-to-toe and heel-to-shin tests. The diver was recompressed on an extended USN Table 6 with significant improvement but had minor neurological abnormalities post-treatment. These cleared with two additional treatments over the next two days.

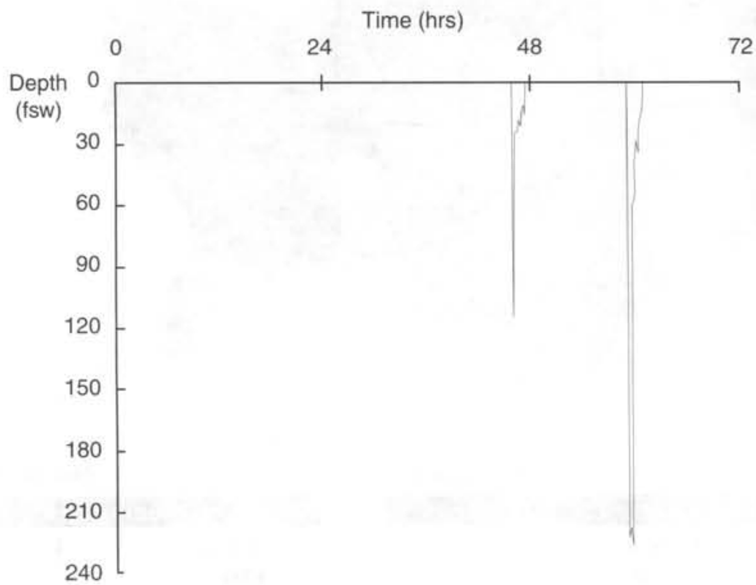


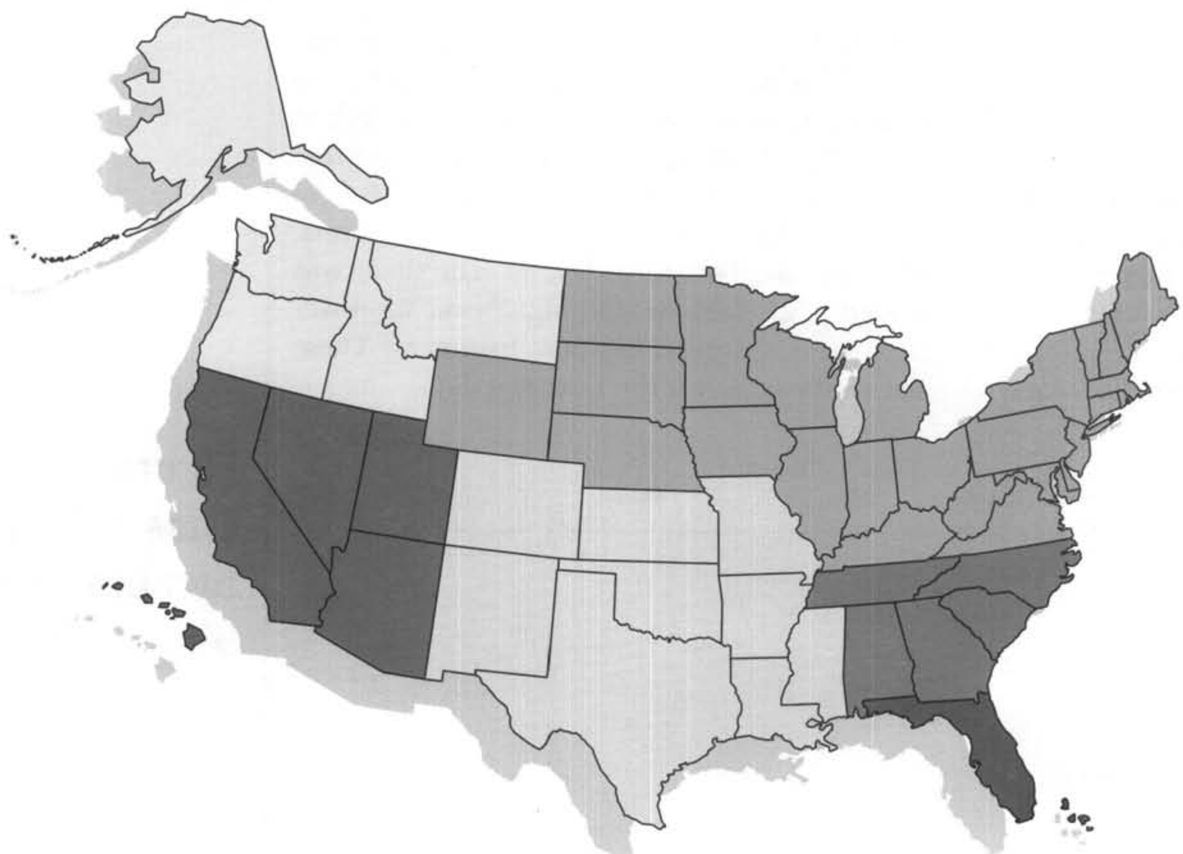
Figure 113. Case 4. Vestibular Symptoms After Six Trimix Dives.

Table 4 summarizes the diving activity of PDE divers by symptom category according to the mean number of dive days, the mean number of dives, the mean dive depth, and the mean maximum dive depth in the series. Divers with Ambiguous symptoms had made deeper dives than divers without DCS. Divers who were recompressed had dived a day longer than the other divers, had made more dives, and had a greater maximum depth.

Table 4. Diving Activity by Symptom Category

Category	Days Diving	Number of Dives	Depth	Maximum Depth
1,467 Divers without DCS	3.9	9.1	70 fsw	98 fsw
11 Divers with Ambiguous Symptoms	3.6	8.5	94	119
4 Recompressed Divers	5.0	14.5	94	149

INJURIES & FATALITES BY REGION & STATE 1987-97



Southeast Region	Fatality	Injury
Southeast Region	**346**	**2811**
Alabama	4	82
Georgia	5	97
North Carolina	13	245
South Carolina	4	71
Tennessee	3	24

Southwest Region	Fatality	Injury
Southwest Region	**130**	**1291**
Arizona	3	60
California	120	1186
Nevada	4	5
Utah	3	33

Northeast Region	Fatality	Injury
Northeast Region	**121**	**918**
Connecticut	3	82
Delaware	2	0
Maine	10	66
Maryland	1	124
Massachusetts	24	63
New Hampshire	0	0
New Jersey	22	77
New York	23	262
Pennsylvania	17	178
Rhode Island	10	4
Vermont	1	0
Virginia	5	44
West Virginia	3	0

Gulf Region	Fatality	Injury
Gulf Region	**41**	**826**
Arkansas	6	7
Colorado	0	94
Kansas	0	14
Louisiana	7	177
Mississippi	2	8
Missouri	6	36
New Mexico	4	17
Oklahoma	2	24
Texas	14	446

Midwest Region	Fatality	Injury
Midwest Region	**37**	**386**
Illinois	2	106
Indiana	2	29
Iowa	2	2
Kentucky	2	9
Michigan	10	73
Minnesota	2	62
Nebraska	0	3
North Dakota	0	0
Ohio	5	59
South Dakota	1	0
Wisconsin	13	0
Wyoming	0	0

Northwest Region	Fatality	Injury
Northwest Region	**54**	**515**
Alaska	4	8
Idaho	0	3
Montana	3	10
Oregon	6	81
Washington	41	414

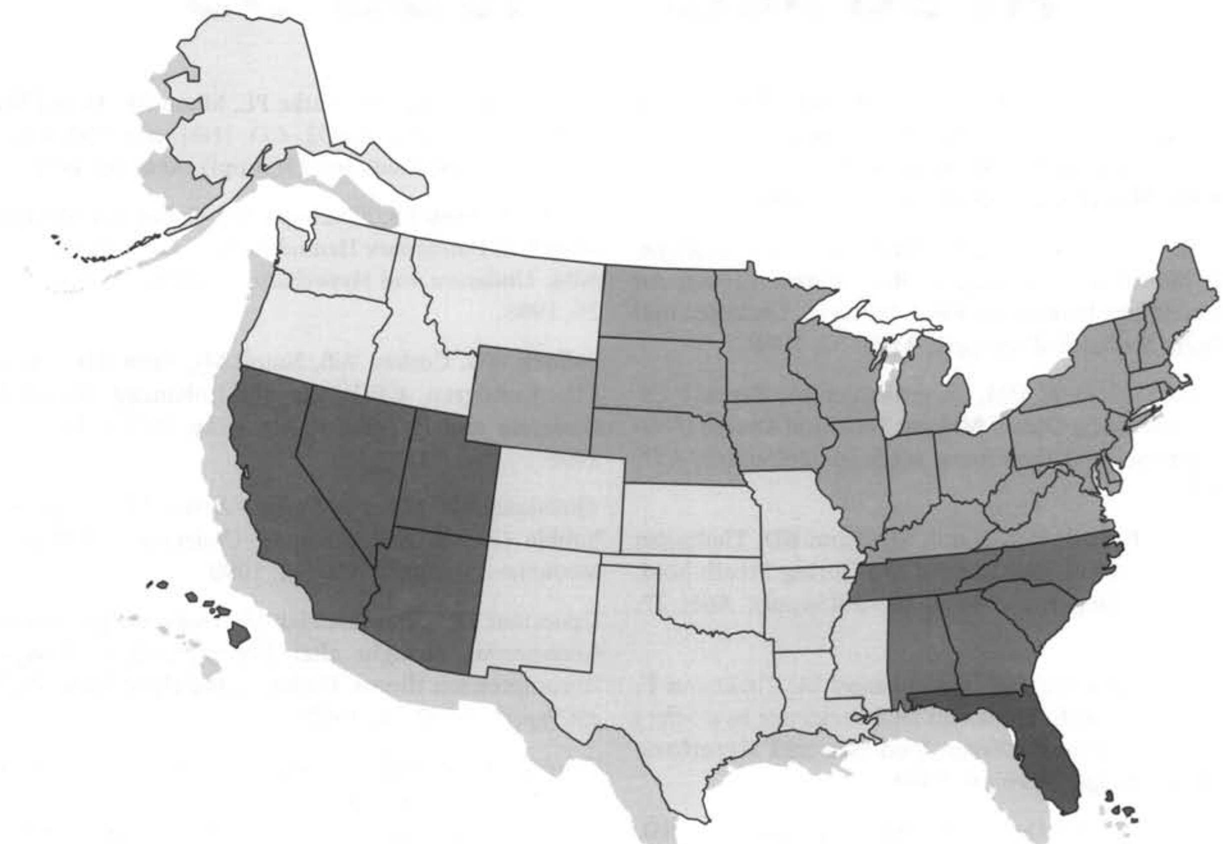
Pacific Region	Fatality	Injury
Pacific Region	**54**	**506**
Hawaii	38	506
US Territories	38	

Caribbean Region	Fatality	Injury
Caribbean Region	**92**	
Florida	317	2272

Mexico/Central America Region	Fatality	Injury
	75	

Other (Canada, Europe)	Fatality	Injury
	17	
Total State	769	7163

INJURIES & FATALITES BY REGION & STATE 1998



Southeast Region	Fatality 24	Injury 94
Alabama	1	2
Georgia	1	2
North Carolina	1	12
South Carolina	0	1
Tennessee	0	0

Southwest Region	Fatality 9	Injury 32
Arizona	1	1
California	8	26
Nevada	0	2
Utah	0	3

Northeast Region	Fatality 13	Injury 36
Connecticut	0	0
Delaware	0	0
Maine	1	5
Maryland	0	1
Massachusetts	4	2
New Hampshire	1	0
New Jersey	2	15
New York	2	1
Pennsylvania	1	8
Rhode Island	0	1
Vermont	0	0
Virginia	2	3
West Virginia	0	0
Washington, DC	2	0

Gulf Region	Fatality 3	Injury 9
Arkansas	6	0
Colorado	0	1
Kansas	0	0
Louisiana	0	4
Mississippi	0	0
Missouri	2	0
New Mexico	0	1
Oklahoma	0	0
Texas	1	3

Midwest Region	Fatality 4	Injury 11
Illinois	0	2
Indiana	1	0
Iowa	0	0
Kentucky	0	0
Michigan	1	2
Minnesota	0	1
Nebraska	0	0
North Dakota	0	0
Ohio	0	2
South Dakota	1	0
Wisconsin	1	4
Wyoming	0	0

Northwest Region	Fatality 3	Injury 48
Alaska	0	0
Idaho	1	1
Montana	0	1
Oregon	2	0
Washington	0	47

Pacific Region	Fatality 6	Injury 49
Hawaii	6	19
US Territories	38	

Caribbean Region	Fatality 14	Injury 56
Florida	19	77

Mexico/Central America Region	Fatality	Injury
	3	69

Other (Canada, Europe)	Fatality	Injury
	5	20
Total State	62	250
Total Region	84	424

Abstracts – 1998-99

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