TABLE 3

PROBABLE STARTING CAUSES AND NUMBER OF RECREATIONAL FATALITIES

A.	**Medical and Injury Causes**	39	
1.	Possible exhaustion, embolism or panic		15
2.	Diagnosed embolism		16
3.	Cardiovascular event		5
4.	Aspiration of vomitus, etc.		3
B.	**Environmental Causes**	19	
1.	Lost/out of air in cave		9
2.	High waves/surf		3
3.	Strong current		2
4.	Entangled in kelp/weeds		1
5.	Entangled in external lines		1
6.	Suspected shark attack		1
7.	Lost in wreck		2
C.	**Equipment-Related Causes**	4	
1.	Overweighted at depth		2
2	Weight belt tangled in BC straps		1
3.	Faulty tank pressure gauge		1
D.	**Causes not defined**	14	

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THE DIVERS ALERT NETWORK REPORT 1988 COVERING DIVING ACCIDENTS IN 1987

John Knight

The Divers Alert Network (DAN) is the United States equivalent to the Australian Diving Emergency Service (DES). The DAN 1988 report makes interesting reading with masses of tables and figures. This is an attempt to convey those parts of the report that I found most interesting. The report is strong on tables but there is little text, which makes the interpretation of the tables difficult. All the tables in this paper have been constructed from, or are modified from, the tables in the report. Any errors of interpretation in this paper are mine.

The report states that DAN received 402 case reports from the US and Caribbean in 1987. 74 were not sports divers so were excluded, 63 histories were too incomplete to be used, so 265 cases were left for study. 149 (56.2%) of these decompression accidents came from the South East region, which includes Florida and the Caribbean, presumably reflecting the large numbers who dive in these tourist areas. Somewhere the mathematics are incorrect as most of the analyses were done on 264 cases with the odd one using 265. The mathematics get queerer when the case reports are broken down by region, as the cases tabulated by states in regions as having been reported in 1987 add up to 557, including 92 cases of arterial gas embolism (AGE) or decompression sickness (DCS) and AGE, instead of 402.

Symptoms and signs

DAN uses a Type I and Type II classification for DCS. Only pain, rash and itching are classified as Type I which provided 31 cases (6 female, 25 male) compared with 204 (51 female, 153 male) of Type II. For some of the analyses a disease severity code was used. Type I DCS was Code 1. Codes 2-5 were Type II and Code 6 AGE. Code 2 patients had "pain, numb/tingle, headache, skin sensation" symptoms. Code 3 "Ringing ears, dizziness, pain, fatigue, reflex". Code 4 "weakness, numb/tingle, breathing, nas/vomit, hearing loss, skin sensation, personality, walk/standing", while Code 5 had "visual-dis, speech-dis, weakness, paralysis, bladder, bowel", whether the whole constellation of symptoms and signs had to be present for each code is not spelt out. These cases who were semi-conscious or unconscious, who had convulsions or who had bilateral paralysis were classed as AGE. There were 29 (7 female, 22 male) cases classified as AGE.

Experience

The table headed "Years Diving Experience and Diagnosis Code. Analysis variable; Average number of dives a year", deals with the number of dives a year rather than years of diving. The minimum of 0 dives a year is unlikely to be achieved by a diver developing symptoms, while the maximum of 999 dives a year seems improbable, involving as it does 3 dives a day for 269 days a year and 2 a day for the remaining 96 days, for sports divers diving for fun. But American's on diving holidays in Australia have been known to do 7 dives a day. At this rate only 143 days diving would be needed for 999 dives.

Age

The ages and sex of the sample are shown in Table 1. Nearly half the victims (47%) were aged from 30 to 39. From the data presented one cannot guess why they figure so prominently. Based on the Australian diving community most of these people would have been diving for some years. I would hazard that some had got into trouble from over confidence of the years of trouble free diving; while others

TABLE 1

DIVERS AGE AND SEX

Age	Female	Male	Total	%
10-14	-	2	2	0.8
15-19	-	10	10	3.8
20-24	6	21	27	10.2
25-29	14	34	48	18.2
30-34	17	47	64	24.2
35-39	18	42	60	22.7
40-44	6	25	31	11.7
45-49	-	11	11	4.2
50-54	1	2	3	1.1
55-59	1	2	3	1.1
60-64	1	4	5	1.9
Total	64	200	264	100

TABLE 2

CERTIFICATION

	Female	Male	Total	%
Basic	14	28	42	15.8
Open Water	21	73	94	35.5
Advanced	17	42	59	22.3
Dive Master	5	10	15	5.7
Instructor	5	26	31	11.7
Other	-	1	1	0.4
None	-	11	11	4.1

could blame a return to diving after some years "retirement", and many would be at risk from not really understanding the decompression tables.

Certification Levels

The divers certification levels are shown in Table 2. These were a surprisingly high number of instructors in the sample when one considers the small proportion of divers who become instructors in Australia.

Depth and time of the precipitating dive

The report includes a graph of depth versus time for the precipitating dive. There is the USN no-decompression limit line running through the scatter of divers. Each diver is represented by a different symbol depending on whether the dive was the first, second, third, fourth, fifth or sixth for the day. One of the symbols on the chart, a solid square, does not appear in the key. It could be a printing error for a thick walled square (three dives that day) so I have counted it as such. By my count (there being no text to go with the graph) there were 72 divers who got into trouble after their first dive, 57 after the second dive, 50 after the third dive, 10 after the fourth dive, 4 after the fifth and 3 after their sixth dive of the day. This gives a total of 194 divers. 40 divers had dived dives outside the USN no-decompression limits. 16 of them were doing their second or later dive for the day. Unfortunately I could find no discussion of the repetitive nitrogen loads of the 122 divers on the graph who had dived more than once on the day of their accident. I suspect that many had not used the tables correctly.

Delay in seeking treatment

The delays in seeking advice were considerable. Only 124 (47%) contacted DAN within the first 12 hours. Of these 26 had AGE, the other 3 AGE cases rang before 24 hours had passed. Of the 235 cases of DCS only 98 (41.7%) made contact in the first 12 hours, 44 (18.7%) others contacted DAN in the next 12 hrs. Only 142 (60.4%) made contact in the first 24 hours. The next 24 hours brought to light another 43 cases (18.3%). The third day 22 people (9.4%) contacted DAN, on the fourth day another 6 rang, all later than 84 hours after the incident. 22 people waited till the 5th day or later to contact DAN. As a result the average times to contact are high, 2 days 15 hours for Type I, and 1 day 15 hours for Type II. By contrast the average time to contact for AGE was 3 hours.

Delays in achieving recompression

All the cases of AGE were recompressed within 24 hours 25 (86%) in the first 12 hours. Only 8 (26%) of Type I DCS cases were recompressed within 12 hours, 18 (58%) were under pressure within 24 hours, 4 were treated in the next 24 hours and 4 more the next day. 5 people took more than 4 days to present for treatment. The delays in Type II cases were equally depressing. 80 people (39%) were recompressed within 12 hours, 107 (52.5%) saw the inside of a chamber within 24 hours. In the next 48 hours another 46 (22.5%) were treated and 19 the next day. 13 presented for treatment on the fourth day. Surprisingly 19 (9.3%) presented on the fifth and later day.

The average times to treatment were once again distorted by the later comers, being 6 hours for AGE, 2 days and 18 hours for Type I DCS and 2 days and 17 hours for Type II.

Table 3 shows those who delayed for 10 days or more before presenting for treatment, 3 with Type I DCS and 5 with Type II, their treatments and results.

Spontaneous recovery

Of interest is the fact that 28, (2 AGE, 2 Type I, 24 Type II) (10.6%) of the 264 patients had complete relief of symptoms and 78 (12 AGE, 9 Type I, 58 Type II) (29.5%) had partial relief before compression.

Later in the report there is a table that showed that twenty-two people had symptoms which cleared spontaneously or only received first aid. It seems that this group was not recompressed. Table 4 gives the details.

Risk profiles

Once again the mathematics change. Only 214 cases of DCS were analysed, but the AGE cases had grown to 50 as opposed to 29 earlier in the report.

Risk factors for the 264 cases analysed are given in Table 5. The top four risk factors were square dives (71%), no-decompression dives (71%), dives deeper than 24 m (67.5%) and repetitive dives. 64% of the divers who developed DCS did so after a repetitive dive.

I find it difficult to reconcile 71% of the total number of DCS producing dives being no-decompression dives with 42% of the dives being outside the tables. Even if all the decompression dives (29% of the total) had been outside the tables this still leaves 13% of the total dives classified as no-decompression dives which must have been outside the tables, so not no-decompression. Perhaps there is an explanation but it is not in this report.

Asthma

10 Asthmatics appear in the statistics. Table 6 shows the activity of the asthma, diagnosis, time to onset of and first symptoms, whether the diver was within the tables, had buoyancy problems, a rapid ascent or air shortage problems and the water temperature. None of these people smoked. Case 3 had had pneumonia and bronchitis 3 months earlier and Case 7 had had epiglottitis two months before the dive. There appeared to be no relationship in three cases (8, 9 and

TABLE 3
DELAY BEFORE TREATMENT OF 10 DAYS OR MORE

Diagnosis	Time to onset of Symptom	Days before Treatment	Time Treated	Chamber Type	Residual Symptoms
Type I	1.00	11	18	Multiplace	None: Developed Aseptic Bone Necrosis
Type I	.01	10	1	Multiplace	None
Type I	6.00	35	1	Multiplace	Type I pain after 2 months
Type II	1.00	11	18	Multiplace	None
Type II	8.00	30	27	Multiplace	None
Type II	24.00	14	1	Monoplace	Pain only after 2 months
Type II	.05	42	4	Multiplace	Pain with weather changes
Type II	1.00	21	1	Multiplace	None

There is no explanation of the meaning of "Time Treated". It probably means"number of treatments"

TABLE 4
BREAKDOWN OF SPONTANEOUS RECOVERY OR FIRST AID TREATMENT ONLY CASES

Condition	No. of Cases	Time to onset of symptoms	Type of Therapy			Symptoms cleared in 2 days or less
			First Aid	Oxygen	Head down position	
DCS I	1	0:07	1 (Aspirin Only)	0	0	0
DCS II	14	0:00-26:00	5	4	2	8
AGE	7	0:01-0:15	3	2	2	5
TOTAL	22		8	6	3	13

DCS II: All of the cases treated with O_2 cleared on the day of treatment. One case used aspirin with less than 2 day recovery. Three cases cleared without treatment.

AGE: One of the cases treated with O_2 cleared the same day; the other O_2 case cleared 3-4 days after treatment. Three cases cleared in a two day period without any type of therapy.

10) between their DCS and their asthma. These figures bear out the conventional Australian view that asthmatics should not dive.

Flying after diving

70 people flew after the critical dive, 49 of them with 24 hours. 7 AGE cases were air evacuated for treatment. I suspect that there is a misprint in the report and that there were 5 Type I cases, two of which were air-evacuated for treatment. The other 3 developed symptoms either during or shortly after the flight. The remaining 37 cases all had Type II DCS. 7 flew with symptoms, 6 of them being evacuated. 4 of the 7 had dived within the USN tables. One flew after treatment. The other 29, 21 of who had dived within the USN tables, developed their symptoms during or after the flight. Flying within 24 hours of a dive is obviously risky!

Of the 21 cases who flew more than 24 hours after the last dive only 2 developed symptoms during the flight. All the others had symptoms before the flight. 3 unfortunates developed recurrences, after full relief by earlier treatment, during or after the flight. Two were retreated and left

TABLE 5
RISK FACTORS

Risk Factor	% of 204 cases of DCS	% of 50 cases of AGE
Square dive	71	90
No decompression dive	71	88
Deeper than 24 m	67.5	52
Repetitive dives	64	24
Second, or later, continuous day of diving	55	46
Current	43	30
Outside table	42	22
Fatigue	38	32
Exertion	36	22
Single dive	36	76
Single day's diving	33	50
Decompression diving	29	12
Multilevel diving	29	10
Less than 1 year's experience	25	32
Rapid ascent	23	48
Cold water	20	20
Alcohol	20	16
Equipment Problems	20	16
Smoker	18	12
Previous DCS	17.5	4
Buoyancy problem	14	28
Diving after a day's break from continuous diving	12	4
Lower air or out of air	10	22

symptom free while the one who was not retreated remained with residual symptoms. These three flew up to 8 days after the dive. Nitrogen bubbles take a long time to disappear.

Equipment failure

41 people had equipment failure as a contributing factor to their problems. Table 7 gives the details. 29 divers (70%) made a rapid ascent as a result of their equipment failure. Failure of a regulator, buoyancy vest problems and weight belt problems were usually (22/29, 75%) associated with a rapid ascent. To quote from the report: " There would seem to be a direct cause and effect between some equipment failures and arterial embolism. The relationship between decompression sickness and equipment problems is less clear and no firm conclusion can be drawn.

Not using necessary equipment

25 people (9.5%) were noted not to be using a depth gauge. 39 (14.4%) were noted not to be using a timing device. 20 people (7.5%) were noted not to be using a buoyancy compensator. These percentages seem high in the face of modern teaching, diving magazine editorials and persuasive advertising. There is no indication in the report as to how many non-users of equipment doubled up on their stupidity. But at least 39 (14.4%) of the DAN cases were diving stupidly by having at least one essential item of equipment missing and the percentage could be (if none overlapped) as high as 31.4%.

Unfortunately these figures cannot be fed into the risk table (Table 5) as, although the total number of cases is much the same, the breakdowns are different. These figures are based on 29 cases of AGE and 235 of DCS. The table is based on 50 cases of AGE and 204 cases of DCS.

Decompression computers

40 people developed problems when using a computer. For reasons that are not stated, the 5 who misused their computer, the 2 with AGE, the 36% nitrox user, and the one with the unspecified profile were excluded from analysis.

Of the remaining 31 cases 22 dives (71%) were outside the USN tables. 2 were bent using their computers for a single dive. Both were multilevel decompression dives outside the USN tables. 9 others were bent diving repetitive dives in a single days diving. The precipitating dives were 1 square dive with no decompression requirement, 4 square

TABLE 6
ASTHMATICS

Case No.	Diagnosis	Asthma: Previous Current	First Symptom	Time to onset.	Within Tables	Low on or Out of Air	Buoyancy Problem	Rapid Ascent	Water Temp°C
1	AGE	Previous	Dizzyness/ Disoriented	.04	Yes	Yes	-	Yes	22
2	AGE	Both	Unconscious	.00	Yes	-	No	Yes	21
3	AGE	Both	Hip & Chest Pain	.01	Yes	-	Yes	Yes	26.5
4	Type II DCS	Previous	Headache	.02	Yes	Yes	Yes	Yes	28
5	Type II DCS	Previous	Back Pain Numb/Tingle	.05	No	-	-	-	23.5
6	Type II DCS	Previous	Extreme Fatigue	.30	No	-	-	Yes	Cold
7	Type II DCS	Both	Numb/Tingle (3 hrs later complained of chest pain)	1.00	Yes	-	Yes	Yes	14
8	Type II DCS	Both	Nausea Vomiting and Fatigue	4.00	Yes	-	-	-	22
9	Type II DCS	Both	Numb/Tingle	6.00	Yes	-	-	-	65
10	Type II DCS	Both	Numb/Tingle	32.00	No	-	-	-	26.5

TABLE 7

EQUIPMENT FAILURES

	Total	DCS	AGE
Regulator	13	10	3
Buoyancy vest	5	4	1
Weight belt	8	7	1
Dry suit	3	3	0
Inflation hose	5	5	0
Unknown	1	1	0
Pressure Gauge	2	1	1
Watch	2	2	0
Back pack	1	0	1
Wet suit problem	1	0	1
TOTAL	41	33	8

TABLE 8

DIVE CHARACTERISTICS

COMPUTER USERS AND TABLE USERS

Dive	31 Computer Users	180 table users
	%	%
Square	32	79
No-stop	48	75
Multiday	74	65
Repetitive	77	60
Single day	26	40
Single dive	23	35
Decompression	52	25
Multilevel	68	21
Outside USN Tables	74	37

decompression dives, 3 multilevel dives with no decompression requirement and a multilevel decompression dive. 8 were outside the USN tables.

20 cases resulted from multiday diving. 5 came to grief on the first dive of the day after at least one day's diving. 1 did a square dive with no decompression requirement, 3 did multilevel dives with no decompression requirement and one did a multilevel dive with decompression. 2 of these dives were outside the USN tables. 15 came to grief during repetitive dives. 2 did square dives with no decompression requirement. 2 did square dives with decompression. 5 did multilevel dives with no decompression requirement and 6 did multilevel decompression dives. 10 of this group were outside the USN tables.

Over half the computer users (62.5%) came to grief after first dives to less than 30 m. However this table (disease severity code by depth of first dive) has a denominator of 40 cases, but no cases of AGE. If the report is dealing with all dive computer users there should be 2 cases of AGE. If the previous exclusions were in force there should be only 31 cases in all. Another mathematical puzzle.

Decompression Meters vs Tables

180 divers in this series developed their DCS after using the USN tables. There were 40 dive computer users, nine were excluded from analysis because "the computers were used improperly, or there were symptoms of air embolism". While it is reasonable to exclude the 2 cases of AGE in a comparison with safety of the USN tables excluding the others; detailed in the paragraph as decompression computers, weights the scales in favour of the decompression meters, as it is highly improbable to say the least (see page114 of this issue) that every diver using the tables could use them properly.

Of the 31 computer divers 68% had Type II DCS while 79% of the table users had Type II DCS. Not a significant difference.

The 31 computer divers estimated a collective total of 1,609 dives "per year", an average of 51 dives a year. The 180 table divers claimed a total of 8,100 dives "per year", an average of 45 dives a year. "Per year" appears to refer to the dives done in the 12 months before the incident. The risk of DCS for computer users was calculated as 1.9% and 2.2% for table users. Again not a significant difference.

The characteristics of the dives are detailed in Table 8. The figures confirm the unsafeness of square dives. The high rate of no-stop dives may partly be due to the exhortations to sports divers not to do decompression dives. Multiday diving is a high risk activity as is repetitive diving using a decompression meter. No comments about brands of meter were made because of the small sample. In later years, as the sample grows, it should be possible to construct a "best buy guide"! Multilevel diving with a computer seems to be more dangerous than with the tables, but this may merely represent the difficulty of calculating multilevel dives without a computer.

TABLE 9
DEPTH AND DCS

Depth m	31 Computer users % DCS	180 table users % DCS
above 18	2.5	15.5
18-21	2.5	11.5
21-24	2.5	8.5
24-27	19.0	17.0
27-30	13.0	15.0
30-33	19.0	8.0
33-36	6	7
36-39	6	8
39 and deeper	26	9

Reconstructed from slide 10 of the DAN report.

Differing dive depths of the deepest dive on the day seemed to influence the appearance of DCS differently for table users and computer users (see Table 9). Tables appear more dangerous at shallower depths, about the same after 26 m until 39 m when computers take over as much more dangerous. I suspect that these findings are more a consequence of the patterns of the dives done than of anything else.

Another quote from the report is applicable "For both computers and tables, repetitive and multiday diving are common risk factors. At the present, a more conservative approach to these types of diving would seem to be indicated in the use of both computers and the Navy tables.

From the DAN figures it would seem that properly used computers for diving no deeper than 30 m are no more and no less dangerous than the USN tables although they allow longer bottom times in multilevel diving. What the result would be if compared with a data base of table users who used the tables correctly is unknown. We do know that many table users use them incorrectly for the second dive. I hope that DAN's data base will, one day, be able to provide the answers.

I hope that the next DAN report will include more text describing the data laid out in the tables as no everyone is adept at extracting information from computer generated tables. Explanations of why the sample size changes from table to table would be much appreciated.

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