1991 SURVEY OF 27 RECREATIONAL MULTI-DAY DIVING OPERATIONS

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Abstract

A survey of 7 training organizations, 18 dive resort operations and 9 live-aboard dive operations was done to determine the repetitive and multi-day diving practices actually in existence today. In this study, which represents an estimated 1.6 million dives annually, the typical numbers of dives per day, consecutive days of diving, surface intervals, depth distribution and the safety practices of recreational divers were identified and recorded.

Introduction

Certification statistics kept by International PADI Inc., a recreational scuba training organization, show that recreational diving is on the rise. In 1980, the PADI organization issued 107,404 certifications, in 1985, 260,319 certifications, in 1989, 397,728 certifications and in 1990, 450,883 certifications. As recreational diving has grown more popular, the number of dive resorts and live-aboard dive boats has increased to meet this consumer demand. Both dive resorts and live-aboards offer opportunities for repetitive diving over consecutive days. At the same time, it must be recognized that little test data exists for decompression protocols beyond three or four repetitive dives, or for several consecutive days of diving. While it is intuitively clear from anecdotal reports that recreational repetitive multi-day diving is beginning to push beyond the body of tested decompression practices, it is unclear as to what extent. For example, anecdotal reports of five or more dives daily for six days consecutively on live-aboard boats are common. While there's no proven risk from this type exposure, this type of diving is untested. This study was initiated under the direction of Richard D Vann, Ph.D., Director of Applied Research at the F.G. Hall Laboratory, Duke University Medical Center, to uncover the range of common, intensive recreational multi-day repetitive diving activities.

Methods and materials

The 1991 DEMA (Diving Equipment Manufacturers Association) Show in Las Vegas, Nevada, offered an ideal opportunity to conduct the survey. The annual DEMA show brings together, among other dive industry members, global representatives of dive resorts and live-aboard dive boats. Using a confidential survey form (see Appendix), a personal interview was conducted with representatives of resorts and live-aboard operations at the 1991 DEMA Show. The interviewer asked probing questions on procedures and sought to capture reports on standard operations and decompression procedures. Dr. Vann assisted this questioning by reviewing the survey form prior to the survey.

Eighteen dive resorts, nine live-aboard dive boats and seven training organizations were interviewed. It is significant to note that some operations operate more than one live-aboard boat or resort, so the number of such boats and resorts represented by this survey exceeds 27. An effort was made to give the survey a worldwide distribution, though the Caribbean, which has a large concentration of such operations, has more weight.

A guarantee of confidentiality was given to interviewees to encourage accurate reporting free of competitive concerns or possible complications with their respective training organizations. All interviewees worked first-hand with diving operations. Second-hand reports of diving practices were excluded.

Many interviewees answered questions with ranges rather than specific numbers; in many cases, it was necessary to use a single number from such ranges to derive data. In these instances, the lowest number in the range was used. An example of this the estimation of 1.6 million dives per year being represented by this survey. This was as the total of all dives at all operations as derived in this example:

For an operation reporting 6,000-7,000 divers per year, 7 to 10 days diving per diver per stay and 3 to 6 dives per day:

6,000 X 7 X 3 = 126,000 dives per year.

Specific comments regarding the data accompany some of the following tables.

The survey sought to compare the number of days

TABLE 1

DISTRIBUTION OF OPERATIONS

Location	Resorts	Live-aboards
Worldwide multiple operations	2	2
Australia		1
Bahamas	2	2
Bonaire	1	
Cayman	4	
Cozumel	2	
Fiji	1	
Florida	1	
Hawaii	1	
Honduras	1	
Micronesia	2	1
Red Sea		1
St. Lucia		1

TABLE 2

APPROXIMATE NUMBER OF DIVERS PER YEAR

	Resorts	Live-aboards
1,000 or less	1	4
1,001 - 5,000	9	2
5,001 - 10,000	2	3
10,001 - 15,000	2	
15,001 - 20,000	1	
20,001 - 25,000		
25,001+	1	
No answer	2	

spent at a resort or on a live-aboard with the number of days on which dives were actually made. The ratios of "number of days at operation"/"number of actual dives days" are shown in Table 3.

The averages in tables 3 and 4 came out of the data. "Of operations surveyed" is the average number of days reported by the operations. "Of diver per season" is the average of all the divers at all the operations staying the number of days reported by each operation. In both cases, the lowest numbers were used when ranges were given.

The numbers in table 5, showing the number of dives per day, are based on the lowest numbers reported by each operation. Five (55.5%) live-aboards reported dives-per-day routinely exceeding 5.

Table 6 gives the dive depths typically used at the various operations. Only 5 live-aboards and 12 resorts operations could estimate general dive depth distribution. This distribution is adjusted based on number of dives (based on lowest in ranges) per season at each reporting operation.

Table 7 gives the typical surface intervals. In general, resorts were able to give more accurate estimates of surface intervals. Live-aboards reported greater variation and tended to be more vague.

Reports on DCS from both resorts and live-aboards

TABLE 3

DAYS SPENT AT OPERATION/ACTUAL DAYS DIVING

Ratio days at operation to days of diving	Resorts	Live-aboards	Both Groups
3/2	1 (5.5%)	0	1 (3.7%)
3/3	1 (5.5%)	0	1 (3.7%)
4/3	1 (5.5%)	1 (11%)	2 (7.4%)
4/4	2 (11%)	0	2 (7.4%)
5/4	2 (11%)	0	2 (7.4%)
6/5	0	1 (11%)	1 (3.7%)
7/5	2 (11%)	3 (33%)	5 (18.5%)
7/6	5 (28%)	3 (33%)	8 (29.6%)
7/7	0	1 (11%)	1 (3.7%)
8/6	1 (5.5%)	0	3 (3.7%)
Insufficient information	3 (17%)	0	3 (11%)

TABLE 4

AVERAGES OF DAYS AND DIVES AT OPERATIONS

Average days spent with operation

	Resorts	Live-aboards	Both Groups
Reported by operations	5.66 days	6.55 days	6.00 days
Diver per season	6.39 days	6.64 days	6.44 days

Average days diving

	Resorts	Live-aboards	Both Groups
Reported by operations	4.66 days	5.33 days	4.91 days
Diver per season	4.9 days	5.57 days	5.00 days

TABLE 5

NUMBER OF DIVES PER DAY

Number of dives/day	Resorts	Live-aboards	Both groups
2 or less	13 (72.2%)	1 (11%)	14 (52%)
3	5 (27.8%)	1 (11%)	6 (22%)
4	0	5 (55.5%)	5 (19%)
5	0	2 (22.5%)	2 (7%)
Dives per day average			
Of operations	2.24	3.83	2.77
Of diver per season (16 resorts reporting)	1.95	3.42	2.23

TABLE 6

TYPICAL DIVE DEPTH DISTRIBUTION

Depth range in feet	% of dives Resorts	Live-aboards	Both Groups
0-30	18%	6.0%	16.0%
31-60	31%	54.6%	35.0%
61-90	40%	24.0%	37.4%
91-130	10%	14.8%	11.0%
131+	1%	0.6%	0.6

TABLE 7

TYPICAL SURFACE INTERVAL DURATION AT 18 RESORTS AND 7 LIVE-ABOARDS

Surface Interval	Resorts	Live-aboards	Both Groups
0 to 60 minutes	12 (67%)	2 (29%)	14 (56%)
61 to 120 minutes	2 (11%)	1 (14%)	3 (12%)
121 to 180 minutes	4 (22%)	3 (43%)	7 (28%)
181 to 240 minutes	0	0	0
241 to 300 minutes	0	1 (14%)	1 (4%)

tended to be vague and guarded. No relationship between days dived or number of dives per day and DCS cases reported was found.

The following "worst case' DCS incident rates were derived based on "less than per 1 year" = 1, and using the fewest estimated dives per year.

Resorts:	1 case in 63,882 dives (0.0016%)
Live-aboards:	1 case in 34,300 dives (0.0029%)
Both groups	1 case in 49,996 dives (0.002%)

Table 9 shows computer usage based on averages of percentage estimations by operations and their divers-per-season.

Mutli-level is defined as permitting profiles that extend bottom time beyond the No- Decompression Limit (NDL) of the deepest depth by crediting for ascent to a shallower depth. All live-aboards said they permit multi-level diving. One resort said it permits neither multi-level diving nor computer use. Other resorts that do not permit multi-level diving said they permit divers to use computers, but only as time/depth gauges.

The incidence of decompression diving and the safety

TABLE 8

DECOMPRESSION SICKNESS REPORTED

Cases per years	Resorts	Live-aboards	Both Groups
less than 1	15 (83%)	5 (56%)	20 (74%)
1	1 (6%)	1 (11%)	2 (7.4%)
2	2 (11%)	2 (22%)	4 (14.8%)
3	0	0	0
4	0	0	0
5	0	1 (11%)	1 (3.8%)

TABLE 9

PERCENT OF DIVERS USING COMPUTERS

Resorts	23%
Liveaboards	58%
Both Groups	29%

recommendations of skipping a day's diving (multi-day skip) and safety stops in the various operations is shown in Table 11. Four resort operations reported 3 or fewer days of continuous diving. Multi-day skip was considered "standard" if an operation requires it, or if most divers at an operation routinely take a day off during their stay. Every operation that did not require a safety stop said that it strongly recommends safety stops.

Training Organizations

Seven training organizations, including PADI, were surveyed as to whether their training standards affect multi-day, repetitive diving. There was virtually no difference in any of the organizations. They all allowed a maximum of two training dives per day at entry level. None had restrictions on non-training dives after certification. All advise conservatism when making multiple repetitive dives over multiple days,but no specific guidelines were given.

PADI's Standards, as presented in the PADI Instruc-

TABLE 10

AVERAGE REPORTED PERCENTS OF COMPUTER-USING DIVERS

	Resorts	Live-aboards	Both Groups
In operations permitting multi-level diving.	39.5%	55%	46.8%
Range	5%-90%	5%-95%	5%-95%
In operations not permitting multi-level diving.	19.1%	NA	19.1%
Range	0%-50%	NA	0%-50%

TABLE 11

STANDARD OPERATIONAL PRACTICES

		Resorts	Live-aboards	Both Groups
Multiday skip	Yes	3 (17%)	2 (22%)	5 (18.5%)
Multiday skip	No	11 (61%)	7 (78%)	18 (66.7%)
3 or less days of continuous diving		4 (22%)		4 (14.8%)
Decomp diving	Yes	2 (11%)	3 (33.3%)	5 (18.5%)
Decomp diving	No	16 (89%)	6 (66.7%)	22 (81.5%)
Safety stop required	Yes	12 (66.7%)	7 (78%)	19 (70%)
Safety stop not required	No	6 (33.3%)	2 (22%)	8 (30%)

tor Manual[1], give an example of how training organizations address multi-day, repetitive diving:

"No more than two open-water scuba training dives are to be conducted in a single day for any individual student (the only exception is the Advanced Open Water Diver course, which allows a night dive to be conducted following two daylight dives)."

The PADI Open Water Manual[2] advises:

"Since little is presently known about the physiological effects of multiple dives over multiple days, you are wise to make fewer dives and limit your exposure toward the end of a multi-day dive series."

In The Undersea Journal[3], PADI's instructor journal, PADI members were advised:

"DAN suggests that divers engage in no more than three or four consecutive multi-dive days. For example, on extended trips during which the diver is making more than two divers per day, he should refrain from diving every third or fourth day."

Discussion

From a mathematical point of view, the number of surveys in this project makes a high statistical confidence level difficult. Nonetheless, this does not mean the information is inaccurate and the data strongly suggest that some diving practices are prevalent. If these practices exist to a greater or lesser extent than found in this survey, this survey at least reveals a need for closer examination.

EXTENT OF MULTI-DAY DIVING

There's no question that multi-day diving repetitive diving is wide-spread. The survey showed that the "typical" diver dives about five days during a six-and-a-half day stay at a resort or on a live-aboard. Apparently, taking a day off during a multi-day dive series (multi-day skip), while not uncommon, is not the prevalent practice at resorts or live-aboards. One resort operation that caters for approx. 12,000 divers annually at three resorts said that the multi-day skip had become less common since the release of the new flying-after-diving recommendations, which make it difficult to dive on the last day of the trip.

EXTENT OF REPETITIVE DIVING

While the number of days dived were similar for resorts and live-aboards, there's a tendency to make more dives per day on a live-aboard than when at a resort. The "typical" diver makes 1.95 dives daily at a resort, compared to 3.38 on a live-aboard (about 73% more dives per day). Live-aboard reports reaching 5-6 dives daily were not uncommon, with as high as 10 dives in a day being reported.

SURFACE INTERVALS

Interestingly, resorts showed shorter surface intervals. Apparently, the common resort two-tank morning or afternoon schedule keeps surface intervals at dive resorts short, while live-aboards, which do not have tight schedules to keep, can afford a more leisurely pace between dives. This is supposition supported by the reports. Resorts gave fairly accurate specific intervals, which is consistent with running a regular schedule, whereas live-aboards tended to be more vague and cited little regularity to surface intervals.

TYPICAL PROFILE

It was hoped that a "typical day's dive profile" would be found by this survey. Instead, it was found that there's no such thing across the board. Live-aboard boats had difficulty citing "typical" profiles, so it's impossible to extrapolate a "typical" live-aboard profile, other than diving deep in the mornings and shallower as the day progresses. Several resorts gave their daily profiles, making a rough "typical" resort profile:

First dive: 60 to 100 feet deep for 5 minutes less than the NDL. Surface interval: 30 min to 1 hour. Second dive: 60 feet or shallower for 35 to 45 minutes.

COMPUTER USE

There is a significant number of divers using dive computers, and most operations said the number is growing. The least computer use was found among resorts that do not allow multi-level profiles and among resorts and live-aboards in predominantly shallow (majority of diving above 30 feet) regions. In the latter instance, it can be speculated that because of almost unlimited dive time permitted by tables in the shallows, divers do not perceive a need for the additional time afforded by a computer.

The greatest dive computer use was reported among live-aboards. It can be speculated that the lack of tight schedules permits a live-aboard to grant divers nearly as much dive time as they want, making a dive computer especially useful. One live-aboard that specializes in deep water wrecks reported that without a dive computer, a diver misses most of the dives. Not surprisingly, this operation reported that 95%+ of its customers use computers.

DECOMPRESSION DIVING

Although decompression diving is generally considered beyond the parameters of recreational diving, five operations reported that decompression diving was permitted. This is a surprisingly large portion of the group (18.5%) and could be a fluke caused by the small size of the survey,

or, on the other hand, could indicate that decompression diving among recreational divers is more common than previously suspected.

All but one of the operations that permit decompression diving said they have strict guidelines for decompression dive supervision and minimum experience and/or training levels for participants.

RESTRICTIONS

The survey found that while virtually all resorts enforce guidelines for diving, the degree of restriction varies considerably. Some resorts, in particular, specify the exact dive profile, including depths, bottom times and surface intervals. Other operations stipulate broader rules, such as "Do not exceed the no decompression limits" and other safe diving practices, leaving the diver to use his table/computer to the best advantage within the guidelines.

No operation reported widespread difficulties in getting divers to stay within the limits they set. Operations with the least restrictions tended to show more dives per day and more computer use, suggesting that many divers will take advantage of more dive time if it's available.

No relationship was found between DCS cases reported and the degree of diving restrictions reported by operations. For example, the operation reporting the highest DCS incidence (5 cases per year average) had a restriction of only two permitted per day, and reported that multi-day skip is standard procedure. Another operation that permits decompression dives, dives below 130 feet, and typically offers five dives a day for six days continuously reported only two cases of DCS in seven years.

WHAT WAS SAID

All operations were asked if they specified particular tables, computers or had any other special procedures or considerations that involve dive profiles and DCS avoidance.

The DSAT Recreational Dive Planner and the USN tables were mentioned several times, and Bühlmann tables mentioned once, though no one "required" the use of any particular table, except as in training as specified by training organization standards. Some resorts avoid the issue by dictating maximum dive depths and times. No make or model computer was named in any context, neither as particularly favoured nor as being unacceptable.

Virtually every operation requires or highly recommends safety stops. No other stipulation regarding ascents was made, though it can be inferred that all operations expect divers to stay within the ascent rates specified by their tables or computers.

There was no mention of nitrox, oxygen decompression or other mixed gases associated with professional/technical diving.

Conclusion

DAN diving accident statistics have shown that more DCS accidents occur following multi-day diving, but this may simply reflect the growing number of divers making multi-day repetitive dives rather than any particular risk of DCS caused by current recreational multi-day diving procedures. Without information on the numbers of dives made single-day versus multi-day, it's impossible to ascertain statistically what role, if any, multi-day repetitive diving plays in DCS risk.

The survey found that multi-day repetitive diving is widespread and common among recreational divers, and that much of it involves more than three dives a day, with five and six dives daily not uncommon. Despite possible concerns raised by accident reports, the survey found no particular evidence of unusual risk from multi-day, repetitive diving as it is currently practiced within the recreational community. This survey found a somewhat higher DCS-per-dive rate for live-aboards than resorts, but a) the small survey size plus using "less-than-1-case-per-year = 1-case-per-year" in determining DCS figures makes it hard to have high confidence in their exactness, and b) even the higher rate indicates less than 3 cases in 100,000 dives.

References

1 PADI Instructor Manual. International PAD*I, Inc*. 1987, 1988, 1989, 1990
2 PADI Open Water Diver Manual. *International PADI Inc*. 1988,1989,1990
3 Richardson D. "How much diving is too much?". *Undersea Journal*, second quarter 1990

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