DECOMPRESSION SICKNESS & DEEP AIR DIVING

NSMRL Researchers Show that the Occurrence of Decompression Sickness Among U.S. Navy Divers Making Deep Air Dives is Extremely Low, but that When It Occurs, It is Probably Caused by Individual Differences in Susceptibility Rather than by Pushing the Decompression Table Limits.

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The overall incidence rate of decompression sickness among U.S. Navy divers is consistently well below one-tenth of one percent, a figure which is among the lowest in any diving organization in the world. This very low incidence rate attests not only to the safety of the Navy's decompression schedules but also to the manner in which diving operations are conducted in the Fleet.

However, decompression sickness casualties do occur, and we have the responsibility for examining such accidents in order to determine the possible explanations for them and to devise methods to prevent similar accidents in the future.

The vast majority of Navy dives (over 97 percent) utilize air as the breathing medium and are conducted at relatively shallow depths. Approximately 97 percent of all air dives are to depths shallower than 150 feet of sea water, gauge (fswg). By contrast, the majority of decompression sickness casualties occur in deeper dives. If air dives to 150 fswg and deeper are compared to air dives shallower than 150 fswg, the incidence of decompression sickness in the deeper dives is more than ten times that seen in the shallower dives.

Such a finding probably fails to surprise Navy divers. They know (sometimes from personal experience) that deeper dives are generally more dangerous than shallow dives. They also know the importance of selecting the correct decompression schedule. The Navy Diving Manual Section 7.4.2 addresses schedule selection by stating:

"...As assurance that the selected decompression schedule is always conservative—(A) always select the schedule depth to be equal to or the next depth greater than the actual depth to which the dive was conducted, and (B) always select the schedule bottom time to be equal to or the next longer bottom time than the actual bottom time of the dive..."

The manual goes further by stating:

"NEVER ATTEMPT TO INTERPOLATE BETWEE DECOMPRESSION SCHEDULES. If the diver was exceptionally cold during the dive, or if his work load wa relatively strenuous, the next longer decompression schedule than the one he would normally follow should be selected..."

This suggests that if there is any question (for example: cold water, heavy work load), the next longer schedule should be chosen.

Navy divers are actually taught to be even more conservative. The procedure taught at the Naval School, Diving & Salvage, is as follows:

> If the dive is within 2 feet or 2 minutes of the appropriate schedule, the next deeper and/or longer schedule should be used.

In other words, don't "push the tables." This procedure was recently emphasized in FACEPLATE (see "The Old Master" column, Winter 1976), and allows for depth gauge inaccuracies and so forth. Coming very close to table limits is thought to increase the likelihood of decompression sickness, while dropping to the next deeper and/or longer schedule is believed to add a measure of safety for the diver. Closely related is the belief that most dives that result in decompression sickness are those which do "push the tables."

6,600 Dives Analyzed

During other work involving decompression principles, we became interested in whether or not there is any relationship between "pushing the tables" and the development of decompression sickness.

We obtained data for air dives logged from 1971 through 1975. This information was supplied by the Naval Safety Center and consisted of selected items found on the OPNAV 9940/1 forms ("Diving Log—Combined Accident/Injury Report). Because the majority of decompression sickness casualties occur in deeper dives, we decided to look at all air dives that were decompressed on the 150/10 schedule or more (that is, 150 fswg or greater for 10 or more minutes.) A total of 6,600 such dives were logged during the 5-year period studied.

By comparing the actual depth and bottom time of the dive to those of the decompression schedule used, we were able to classify a dive into one of three categories:

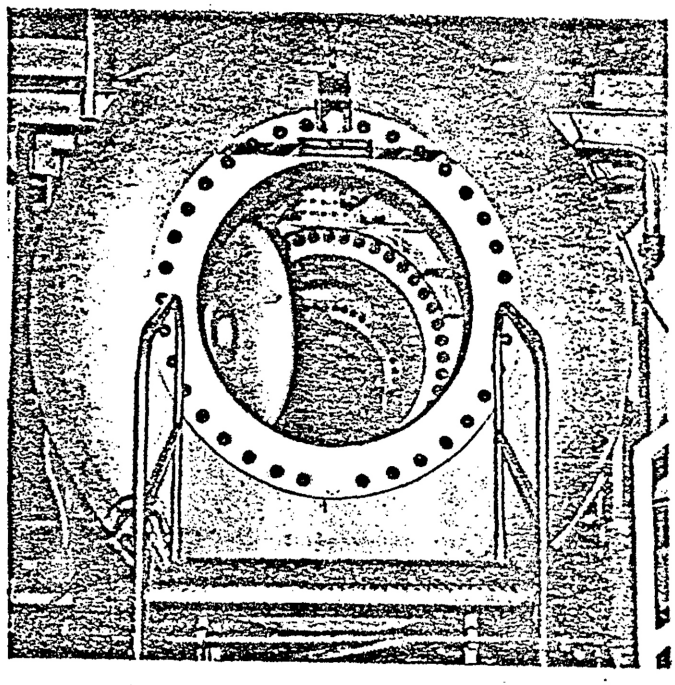
1. Under Schedule Limits
   The actual depth was 3 or more feet shallower than the schedule and the actual bottom time was 3 or more minutes less than allowed by the schedule. (Example: Dive 146 feet for 17 minutes. Schedule 150/20 used.)
2. Near Schedule Limits
   a. 2 *or* 2 — Either the actual *depth was within 2 feet* of the schedule depth, *or* the actual *bottom time was within 2 minutes* of that allowed by the schedule.
   (Example: Dive 146 feet for 18 minutes, or for 20 minutes. Schedule 150/20 used.)
   b. 2 *and* 2—The actual *depth was within 2 feet* of the schedule depth *and* the actual *bottom time was within 2 minutes* of what the table allows.
   (Example: Dive 149 feet for 18 minutes, or 150 feet for 20 minutes. Schedule 150/20 used.)
3. Exceeded Schedule Limits
   Either the actual depth or the actual bottom time exceeded the depth/time limits of the schedule. In other words, inadequate decompression was given. (Example: Dive 149 feet for 23 minutes. Schedule 150/20 used.)

The Findings

A summary of our findings is presented in Table 1. The data in Column 1 of the table reveal the following:

- Nearly 99 percent of deep air dives logged were decompressed in accordance with procedures set down in the U.S. Navy Diving Manual (Category 1 + Category 2).
- Less than 20 percent appear to have followed the NSDS recommendation to use deeper/longer tables if close to the limits (Category 1).
- Over 80 percent of these deep air dives, which are known to be more dangerous, were not decompressed on a deeper/longer schedule even though they were very close to allowable depths and/or times (Category 2a + 2b).
- Over 1 percent of deep air dives received inadequate decompression (Category 3).

The data in Columns 2 and 3 of the table show that the percentage of decompression sickness casualties in each category (under, near, and exceeding the limits) is virtually identical to the percentage of the number of dives that were made in that category, and there is no



statistically significant difference between the two. (For any statistics buffs out there: Yates corrected chi square = 0.255, df = 3, $p > 0.95$.)

Column 3 shows, in addition, that the decompression sickness rate remains nearly the same across all categories. And so it is true that most cases of decompression sickness occur in dives that are approaching the table limits. But that would be expected, because most dives approach table limits. In addition, the casualties appear to be independent of the "2 or 2" rule.

What this may mean is that the Navy schedules work very well when used correctly, and that most of the time decompression sickness casualties may be related to factors other than the dive/decompression profile itself. We already have scientific evidence that some divers are more susceptible to decompression sickness than others (another example of science "discovering" what field personnel already knew). These differences in susceptibility are loosely termed individual variation, and could possibly be related to factors such as age, physical condition, anatomical patterns of small blood vessels, or sensitivity of the body's chemistry to stress.

At any rate, since the data indicate that the rate of decompression sickness is nearly the same whether dives are close to table limits or not, the "2 or 2" rule (admittedly unwritten) may not offer as much of a safety margin as thought.

Of course, the analysis does not take into account work load, water temperature, or other dive-related factors, but it is assumed that such factors would balance out between the categories. These conclusions may give dive supervisors more leeway in their choice of schedules or at least less anxiety when dives are approaching schedule limits.

Special comment should be made about Category 3. Although no casualties were reported, all 88 of these dives involved actual bottom times in excess of the schedule time (for example, a dive to 150 fswg for 34 minutes that was decompressed on the 150/30 schedule.) The average excess was 5.08 minutes. In no dives was the recorded dive depth in excess of the schedule depth. It is impossible to determine whether this is a real finding, or whether this represents recording errors—either in filling out the 9940/1 report forms or in transcribing them into the computer format. We suspect that it is a recording problem, especially in view of the fact that no decompression sickness occurred in this category. But, if Fleet divers are actually following such practices, they should discontinue them and follow standard procedures.

TABLE 1

DEEP AIR DIVES AND DECOMPRESSION SICKNESS CASUALTIES BY CATEGORY

	Column 1		Column 2		Column 3
	ALL DIVES		DIVES LEADING TO CASUALTIES		DECOMPRESSION SICKNESS RATE
CATEGORY	Percent	Number Logged	Percent	Number Logged	Cases per 1000 Dives
1. Under Schedule Limits	17.0	1119	19.0	12	10.7
2. Near Schedule Limits					
a. Within 2 min. *or* 2 ft.	30.7	2028	28.6	18	8.9
b. Within 2 min. *and* 2 ft.	51.0	3365	52.4	33	9.8
Total Near Limits (2a + 2b)	81.7	5393	81.0	51	9.5
3. Exceeded Schedule Limits	1.3	88	0.0	0	*
TOTALS	100.0	6600	100.0	63	Overall Decompression Sickness Rate = 9.5 Cases per 1000 dives

*The number of dives in Category 3 is not large enough to calculate a meaningful decompression sickness rate.