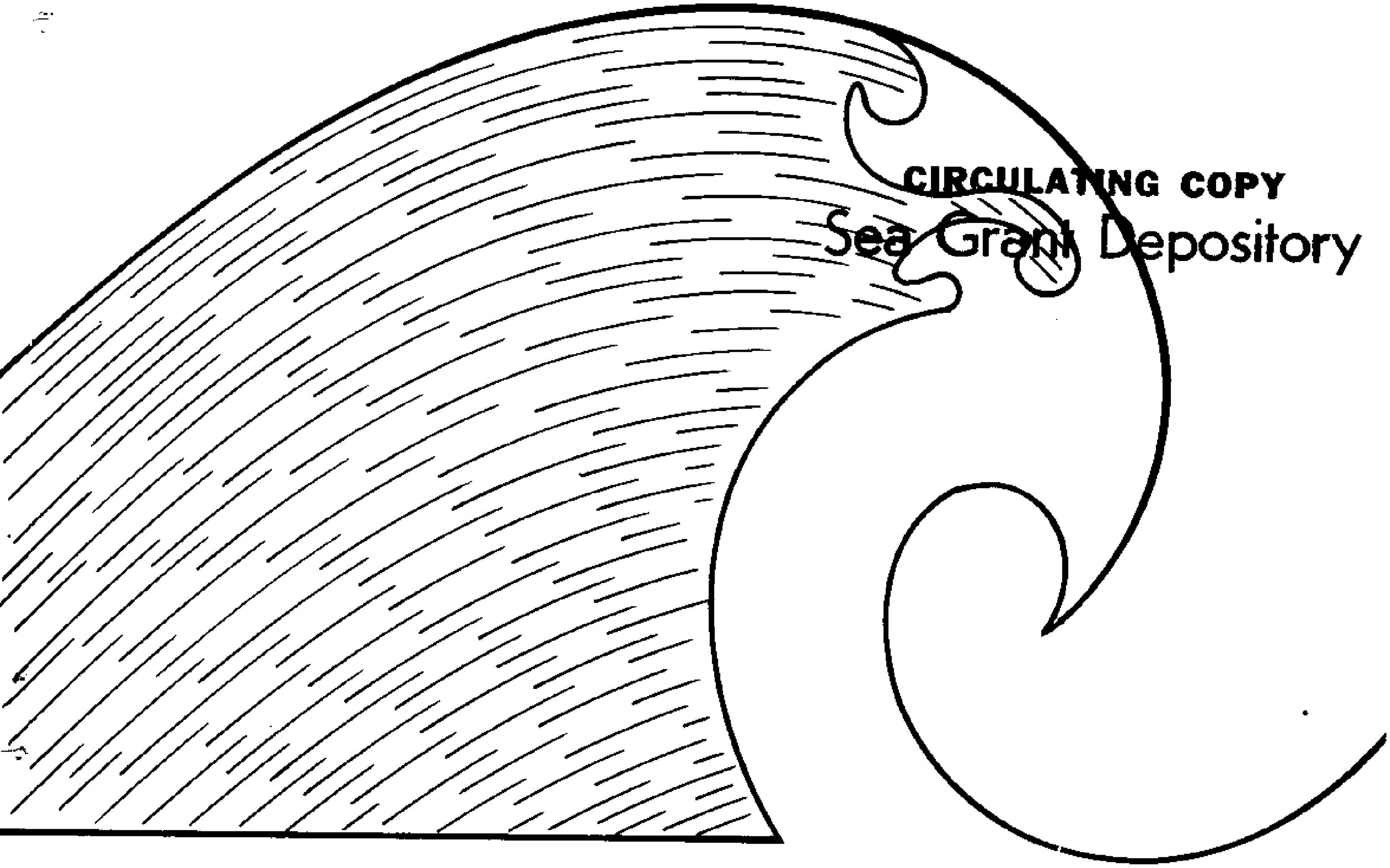


DEPARTMENT OF OCEAN ENGINEERING

SEA GRANT PUBLICATIONS

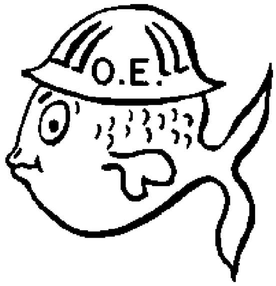
COLLEGE OF ENGINEERING UNIVERSITY OF RHODE ISLAND

2400 HOURS OF SATURATION DIVING

A Statistical Analysis of Tektite II

By J. B. Tenney

SCUBA SAFETY REPORT SERIES, REPORT No. 4



Department of Ocean Engineering - University of Rhode Island

SCUBA SAFETY REPORT SERIES

REPORT NO. 4

2400 HOURS OF SATURATION DIVING, A STATISTICAL ANALYSIS OF TEKTITE II

Prepared by

John B. Tenney, Jr.

University of Rhode Island

Kingston, R.I. 02881

October 1971

Postpaid Price: $2.00

The U.R.I. SCUBA Safety Program

In May of 1969 the Food and Drug Administration of the U.S. Public Health Service provided funds to the Department of Ocean Engineering for a general study of civilian SCUBA safety. Following that original grant, further assistance has been provided by the Sea Grant College program of the National Oceanic and Atmospheric Administration and the U.S. Coast Guard, these grants enabling the Department to expand its safety and engineering studies of civilian diving.

In addition to this report, others dealing with accident statistics, equipment and use studies, and the enhanced use of diving in a variety of applications are available or in preparation.

Report costs are adjusted to cover paper, printing, mailing, and secretarial expenses. Since the Ocean Engineering Department cannot bill or handle invoices, please send your check or money order with your request to Mr. John McAniff, 227 Wales Hall, University of Rhode Island, Kingston, Rhode Island 02881.

Due to the unexpectedly large demand for previous reports, the Department lacks sufficient secretarial assistance to provide notification of new offerings in the SCUBA Safety Report Series to those ordering earlier reports. We suggest that interested members of the diving community write us at yearly or half-yearly intervals noting what reports they own and requesting new ones. We will send available material and bill. Since we are not primarily a publishing house, delays of up to six weeks can be expected when demand is heavy.

In addition to this report, related reports and publications now available are as follows:

> "Sound Localization and Homing of Scuba Divers", T. Leggiere, et.al., Mar. Tech. Soc. J., 4, 1970, 8 pages. Reprints are available free of charge upon request.
>
> "Corrosion of Steel Scuba Tanks", Scuba Safety Series, Rept. No. 1, Univ. of R.I., Two dollars.
>
> "Skin and Scuba Diving Fatalities Involving U.S. Citizens, 1970", Scuba Safety Series, Rept. No. 2, One dollar.
>
> "Non-Fatal, Pressure-Related Scuba Accidents, Identification and Emergency Treatment", Scuba Safety Series, Rept. No. 3, One dollar.

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FORWARD

Since its inception in 1969, the U.R.I. Scuba Safety Project has been mainly concerned with accident statistics and specialized safety engineering studies of Scuba apparatus. The Tektite II experiment, with its extensive diving times and multiple-use aspects, offered the world diving community an important opportunity to assess the potential of shallow saturation diving and to learn how scientific and engineering tests in the shallow ocean can best be carried forward. There are important safety lessons to be learned from Tektite II but, in addition, there are many other useful facts concerning the relative advantages of rebreathers, the maximum daily work loads that can be expected from divers living on the bottom, and the physical and mental characteristics that make an "ideal" shallow scuba diver. Thus the publication of this excellent study by Mr. Tenney, himself an engineer, experienced diver, and Tektite II participant is in keeping with the basic safety orientation of the earlier U.R.I. work and also broadens our concerns to encompass the general advancement of civilian diving in the United States.

It is unlikely that many amateur divers will have the opportunity to work from shallow habitats for the next few years, although we forsee an increased use of these devices for general scuba education. Nevertheless, Mr. Tenney's statistical studies of the Tektite experience are of use to all serious divers.

Some readers of this report will lack the statistical background needed to fully understand the several tables of data used by Mr. Tenney. In general, the basic meaning of the data should be clear from the written statements, without regard to the statistical tables. A comparison is said to be "significant" when there is only a slight probability of it occurring purely by chance or "luck". "Correlation" defines the degree of relationship between two variables. For example, age and death rate would show a strong positive correlation for humans. That is, the older a person is, the greater the probability that he will die. Longevity and smoking-incidence in a given age group shows a negative correlation, the two being inversely related. Correlation coefficients vary from plus to minus one with a value of zero indicating that the two variables have no interaction or causative relationships with each other.

The Scuba Safety Series will be pleased to review materials of this sort appropriate to our purposes and to the interests of the world diving community, especially items that are inappropriate for journal or magazine publication because of length or other constraints.

Hilbert Schenck, Jr.
Professor of Ocean Engineering
University of Rhode Island
Kingston, Rhode Island
October 1971

ABSTRACT

The Tektite 2 program was a manned saturation diving program in which an undersea habitat was used to provide a base of operations for scientific divers living and working on the sea floor. In the course of this program the habitat was occupied by 48 scientist and engineer-divers for periods ranging from 12 to 30 days. Each diver made numerous excursions during each 24 hour period under a range of conditions. Safety records maintained from the surface permit a wide range of contrasts to be made on diver performance under field conditions. Typical contrasts which are evaluated include: day-night, male-female, team leader-team member, open circuit scuba-closed circuit rebreather, short mission-long mission and scientist-engineer. In addition, hypotheses are statistically tested concerning duration, frequency and conditions of saturation diving excursions.

Saturation diving is an effective but expensive technique for undersea research and development. The conclusions of this analysis will be of assistance to engineers and program technical planners in selecting crews, determining operational procedures and procuring diving equipment to increase diving time and effectiveness.

I

INTRODUCTORY BACKGROUND

In recent years advances in the development of diving equipment have led to the widespread use of diving for scientific and technical purposes. Until the past decade however man has been effectively tied to the surface despite his equipment. Using whatever technique he chose he was still limited to short stays at relatively shallow depths. His stays on the bottom were limited by considerations of the decompression time required to return to the surface.

Decompression refers to the systematic reduction in pressure which must be followed when a diver returns from depth. The development of scientific decompression procedures and tables begins with work by Prof. J.B.S. Haldane (1907) and for practical diving purposes culminates with the U.S. Navy Diving Manual (1).

Pioneering work by Dr. George Bond of the U.S. Navy led to the concept of saturation diving. Bond proposed that when a diver remains at a fixed pressure for a prolonged period he reaches a point at which his tissues are unable to absorb additional dissolved nitrogen. At this point he becomes "saturated" and the time required for decompression from this depth is independent of the time during which he remains under pressure. This concept was verified experimentally by the U.S. Navy in chamber tests.

Following the verification of the concept based on animal tests and tests on human subjects, the technique was used by Jacques Cousteau in "Conshelf I", the first of a series of demonstrations that a man could live and work in the sea for extended periods. This program consisted simply of moving the pressure chamber from the laboratory to the ocean. By placing the chamber at a fixed depth its occupants could come and go at will returning to the chamber after excursions into the water. In this manner, the penalty of decompression was paid only once - upon final return to the surface. The first demonstration was highly successful and permitted two men to live in a habitat in the Mediterranean near Marseille for a week at a depth of 35 feet. The groundwork was thus laid for the development of equipment and techniques which would extend the depth and the duration of man's thrust into the sea.

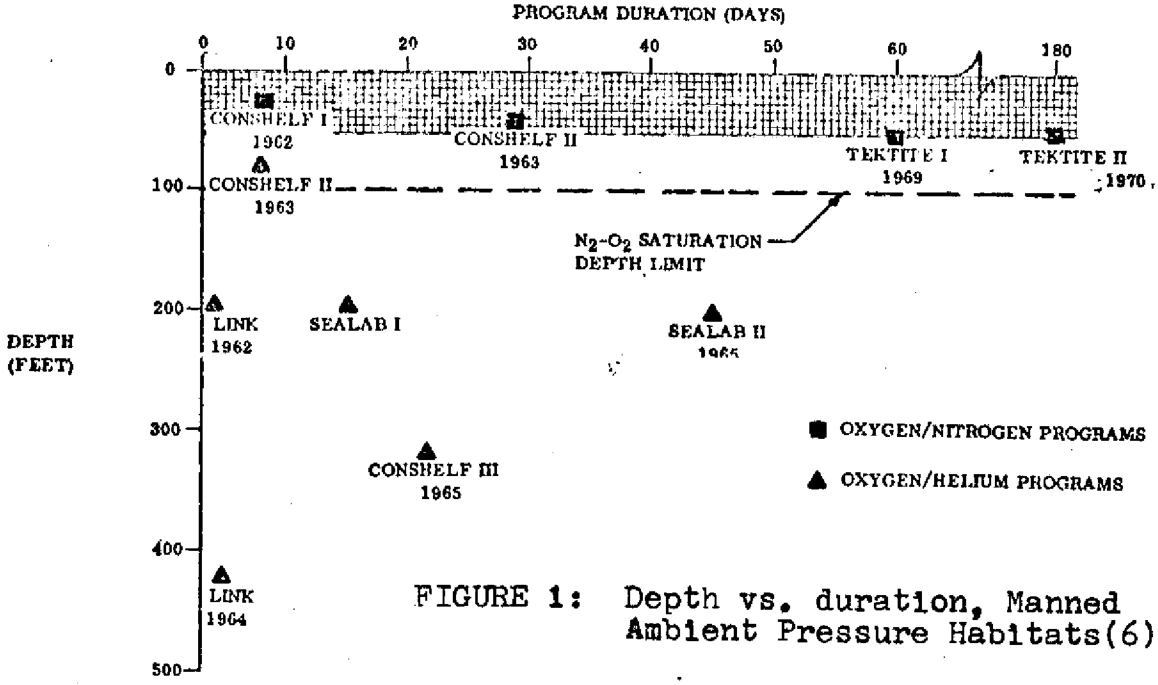

FIGURE 1: Depth vs. duration, Manned Ambient Pressure Habitats(6)

Cousteau's Conshelf I program was carried out in 1962 and virtually coincided with the Man-in-Sea I Program of Edwin A. Link. These well publicized projects were followed by the even better publicized Conshelf II (2) (Cousteau) and Man-in-Sea II (3) (Link). Next the U.S. Navy entered the arena with Sealab I (4) in 1964. This was closely followed by Sealab II (5) in 1965. The literature on the latter programs is extensive and the references cited here are for general information and do not suggest the depth to which these programs have been described.

Figure 1 (6) indicates highlights of habitat programs to date. This figure shows the programs of greatest significance but is by no means complete. More than 35 undersea habitats have been constructed. Most of these are described in Ref. (7) which is the best available survey paper to date.

The most recently completed project, Tektite II, ended in November 1970 after an operational period of more than 7 months. This program was designed primarily to place working scientists in the sea and was, in many ways, a continuation of Tektite I (8). It is highly probable that the number of scientific diving hours accumulated on Tektite II is greater than the total of all diving hours from previous programs.

Thus from a beginning in 1962 the numbers and types of saturation habitats have increased rapidly. More importantly it has been shown that shallow water habitats can be operated by working scientists. Our subsequent analysis of past performance is oriented toward increasing the effectiveness of diving scientists and reducing the cost of scientific work from saturation habitats.

There are numerous problems associated with the use of saturation habitats for scientific work. These stem from the fixed costs associated with equipment and from the recurring costs associated with operational personnel, supplies, maintenance services and equipment replacement. There are technical problems related to equipment and operational problems which arise from administrative and management aspects. Nevertheless the general usefulness of habitats for marine science has been well established by programs to date and the next decade will undoubtedly see advances. One of the recommendations of the Stratton Commission (Commission on Marine Science, Engineering and Resources) dealt specifically with saturation habitats and recommended "a program of fixed continental shelf laboratories. These laboratories, conceived as permanent structures emplaced on the shelf bottom, would include living and working quarters for 15 to 150 men. Some compartments would be maintained at a pressure of 1 atmosphere and others would be pressurized to support divers performing long duration saturation dives." (9)

But the cost and complexity of previous programs may tend to delay subsequent activity. Part of the problem in determining the cost-effectiveness of scientific saturation diving was recognized in a recent report by the Marine Sciences Council. "As in the case of most scientific endeavors it is not possible to carry out cost-benefit analyses since the results of scientific work cannot be assessed in economic terms. Assessments of this type are more difficult when new techniques are in the early stages of development, and many of the costs cannot accurately be measured, let alone the benefits.

One factor which can perhaps be calculated as soon as there is enough evidence from early experience with habitats is the cost of doing certain scientific experiments from the habitat in comparison with doing the same tasks by bounce diving from the surface. The proponents of stationary habitats will in the long run have to demonstrate the superiority of the technique for various depths and uses." (10)

Saturation diving programs are concerned with extending the time a man can spend working productively in the sea. The programs are, in a sense, buying underwater time, and buying it at a high cost. For this reason, the U.S. Navy has undertaken several studies of human performance, as related to divers. Several of these studies stemming from Sealab II are reported in Refs. (11, (12), (13), (14) and (15).

Numerous criteria were evaluated as indicators of performance including age, diving experience, birth order and size of hometown. Other subjective parameters such as fear, arousal, and gregariousness were also measured by self report and correlated with diving performance. The in-water measures selected for evaluation were, number of performance tests, number of sorties and diving time.

These previous studies were oriented toward military divers working under conditions of extreme hazard. Based upon the results of Tektites I and II it appears that many more hours of diving will be spent in the future by non-military diving scientists working under conditions where the hazards are somewhat reduced. For this reason it is appropriate to carefully examine existing records to determine ways in which the future prediction of performance can be improved. The Tektite Programs have provided a large volume of data which will be of benefit in planning subsequent programs and in resolving problems associated with cost effectiveness estimates. In particular, Tektite II provided a relatively large sample size for evaluation.

II

DESCRIPTIONS OF THE TEKTITE PROGRAMS

The Tektite I program was a scientific saturation diving program sponsored by the U.S. Navy. This shallow water habitat program enabled 4 scientists to live and work at a depth of 50 feet for 60 days. During this program which was conducted from February 15 to April 15, 1969, the scientists made daily excursions from the habitat to nearby coral reefs. The literature on this multifaceted program is extensive and Refs. (8), (16), (17), and (18) give a good general overview of the program.

During this program all diving from the habitat was accomplished on conventional double tank SCUBA which permits a single dive of approximately one hour at a depth of 50 feet. In order to continue a task it was necessary to return to the habitat and refill or change tanks. As a consequence diving time was not spectacular and led critics to claim that the program might easily have been accomplished working from the surface. In describing the Behavioral Program, Dr. James Miller, one of the Navy's program managers, indicated "Each man spent approximately 2 hours per day in the water. Although this time could have been greater, even with existing equipment, it is anticipated that a significant increase will take place when equipment is utilized that does not require frequent recharging of SCUBA tanks." (19)

Following Tektite I, the scientist aquanauts reported on their program to the U.S. House of Representatives Subcommittee on Merchant Marine and Fisheries (20). One of the few complaints voiced at the presentation was that diving performance had been hampered somewhat by a lack of the best available diving equipment. At the time of this charge the best existing equipment was in fact under U.S. Navy classification restrictions. The testimony before the House committee included a list of recommended improvements for subsequent programs. At the top of this list was extended duration (closed-circuit) underwater breathing apparatus.

It is possible that the identification of this problem before the committee was instrumental in having the Navy's classification lifted from commercial equipment during the second Tektite program.

The Tektite II Program, like its precursor program, was a scientific saturation diving habitat sponsored by the U.S. Department of the Interior. The goals and objectives of this complex multiagency program are summarized in Table 1. During the program, ten five man teams occupied the habitat for periods which varied from 12 to 30 days. The planned program schedule for occupancy is shown in Figure 2. The program is described in detail in Ref. (21).

The program began on April 4, 1970, and ended in November 1970. Work from the 50 foot habitat was accomplished smoothly and uneventfully (although the proposed use of a smaller habitat at 100 feet was cancelled). During Tektite II much care was taken to insure the safety of participating divers. Surface monitors maintained around the clock vigilance and safety divers were working from small rubber boats and stood by when divers were in the water. Major elements of program safety planning are given in Reference (22).

Table 1 Tektite II Program Objectives

- 0 Provide marine scientists with unique opportunities for underwater research so they may gain more information on the characteristics of reefs and their associated fauna and flora.
- 0 Generate research data on human behavioral dynamics and habitability assessment for small crews in confined living spaces.
- 0 Refine and supplement biomedical information on nitrogen saturation diving to depths of 100 feet.
- 0 Stimulate the growth of ocean sciences and technology - particularly in the area of man-in-the-sea.

Table 2 Selection Criteria for Tektite II Scientist Aquanauts (21)

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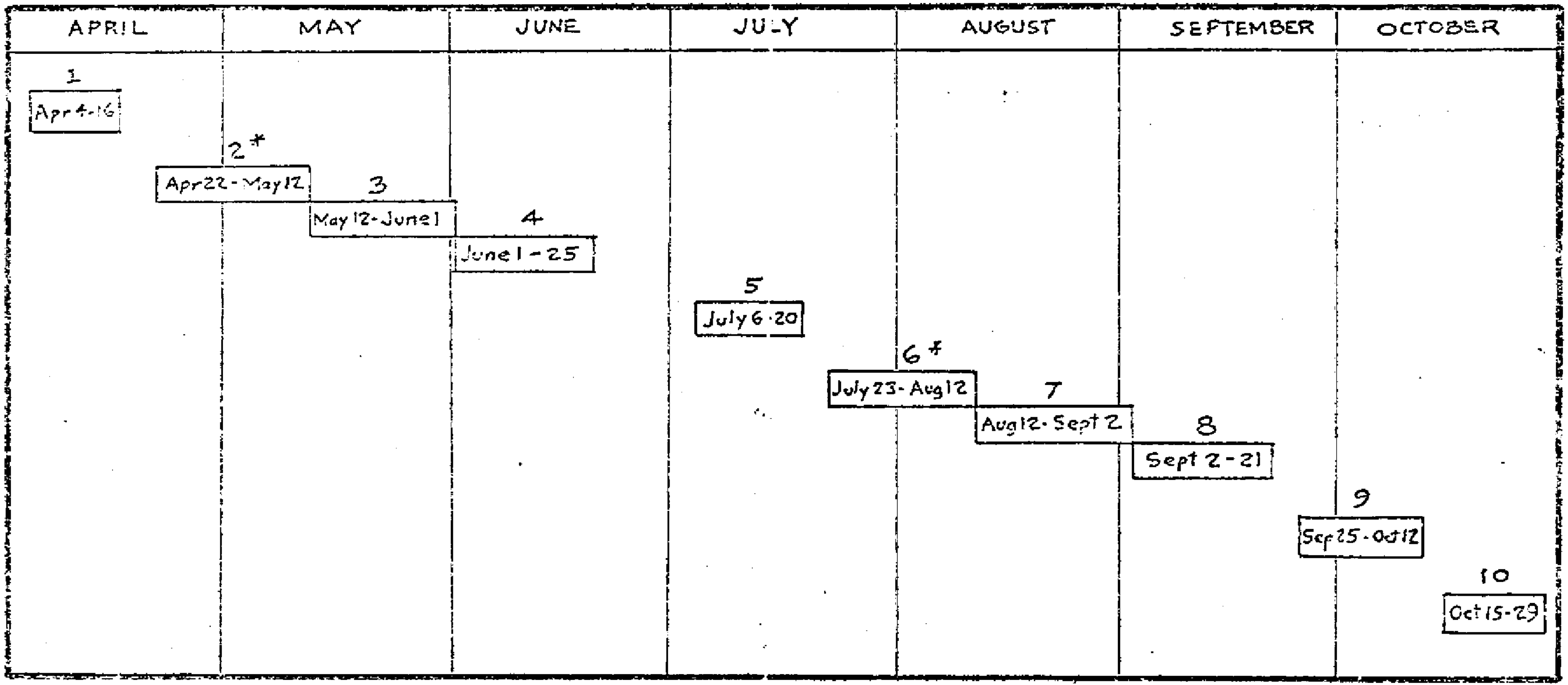
1. Selection of proposed experiment by Tektite Ocean Floor Research Selection Panel.
2. Demonstration of completion of a recognized course of diving instruction. (e.g., NAUI, NAVY, YMCA, etc.)
3. General physical examinations.
4. Special physical examinations as required by Tektite Medical Advisory Panel.
5. In water - proficiency checkout by Tektite Diving Supervisor at the site.



* 3 TEAMS OCCUPIED HABITAT CONTINUOUSLY FOR 60 DAYS. 2 ENGINEERS EACH STAYED DOWN FOR 30 DAYS.

FIGURE 2: TEKTITE II Program Schedule

Diving records for all Tektite divers were maintained continuously during the program by Department of Interior Watch Directors. Information was recorded directly in the Watch Directors Log and no separate diving logs were maintained by individual divers. Primary emphasis was placed on recording correct times for departure and return to the habitat. In some cases the Watch Directors recorded the type of equipment being used by the aquanauts however in many instances it is not possible to determine whether the diver used a full or partial wet suit, single or double air tanks, or carried particular tools or safety devices. In spite of limitations, the Watch Directors Log provides considerable information of great potential value to subsequent programs.

During the program, a total of more than 2400 hours of diving time was accumulated. This body of data is sufficiently large to permit valid statistical analyses to be made.

Participating scientific divers were selected based upon acceptance of their proposed scientific experiment by a screening committee from the Smithsonian Institute. Additionally each scientist aquanaut was required to satisfy a range of acceptance criteria summarized in Table 2.

The experiments performed by the scientists are of interest and in many cases the experiment determines the type of diving that is required. Experiments are summarized in Table 3.

During the Tektite program, dives were made using open cycle scuba, closed cycle scuba and hookah. Open cycle scuba consisted simply of a demand regulator attached to a single or double tank. For purposes of safety and reliability, two separate regulators were used whenever two tanks were used. Single tanks were used very seldom because of their limited duration.

Closed cycle equipment consisted of the General Electric MK10 Mod 0 which was used by Team 2, 3 and 4; the MK10 Mod 3 was used by subsequent teams. Diving scientists were required to complete a course of instruction in the use of these rebreathers and were required to demonstrate in-water proficiency before being permitted to use them. Not all aquanauts employed rebreathers.

Some diving was performed on hookah. A hookah consists of a demand regulator and hose attached to a bottle bank which permits the aquanaut to stay in the water for long periods of time in close proximity to the habitat. The hookah hose on Tektite was quite short limiting its usefulness and as a result it was seldom used. Time spent on hookah was minimal and has been included with time spent on open cycle scuba in order to simplify computations.

The safety record on Tektite 2 was excellent and all planned programs from the 50 foot habitat were completed successfully. Preliminary reports indicate that a large amount of useful scientific work was completed and a final report is currently being prepared by the U.S. Department of the Interior.

As a final note on saturation diving it should be noted that it is a new experience for most scientists. In his "Quick Look" Report to the Department of the Interior, Bill High (Team 1) wrote:

> "The advantages of saturation diving over conventional scuba techniques are obvious but to most scientists the experience is so novel that it is difficult to preplan experiments due to a lack of experience and knowledge of the full potential this type of diving offers."

Table 3 Summary of Tektite 2 Saturation Diving Experiments

Mission	Experiment Title	Investigator
1	"Precise In Situ Measurements of Some Chemical Parameters"	Mr. Richard W. Curry, Mr. Roger J. Dexter - Institute of Marine and Atmospheric Sciences, University of Miami
	"Observations of Fish Behavior in Relation to Fish Pots"	Dr. Alan J. Beardsley, Mr. William J. High - U.S. Bureau of Commerical Fisheries, Seattle
2	"Continuation of Underwater Geologic Studies in the Lameshur Bay Area, St. John, U.S. Virgin Islands"	Dr. H. Edward Clifton, Dr. Ralph E. Hunter - U.S. Geological Survey, Menlo Park, California
	"Ecology, Behavior and Population Dynamics of the Spiny Lobster, Panulirus argus, in the Virgin Islands"	Mr. John VanDerwalker, Tektite II Program Office and Mr. Ian Koblick, Government of the Virgin Islands
3	"Continuation of Underwater Geologic Studies in the Lameshur Bay Area, St. John, U.S. Virgin Islands"	Mr. R. Lawrence Phillips, U.S. Geological Survey, Menlo Park, California and Mr. D. Bowman, Marine Biomedical Institute, Galveston, Texas (continuation of 2-50)
	"Dynamics of Predation by Invertebrates and Fishes on Coral Reef Associations"	Dr. Charles Birkeland, Brian Gregory - University of Washington
4	"Passive and Experimental Bio-Acoustical Studies on Marine Organisms in Their Natural Habitat"	Dr. Thomas J. Bright, Dr. William W. Schroeder - Texas A&M University, College Station, Texas
	"Comparative Studies of Sublittoral Vegetation in the Virgin Islands and the New England Coastlines"	Dr. Arthur C. Mathieson, Mr. R. Fralick-University of New Hampshire, Durham
5	"The Ecology and Behavioral Patterns of the Motile Fauna Associated with Tropical Marine Soft Bottom Communities	Dr. Renate True - Tulane Medical School, New Orleans

Table 3 Summary of Tektite 2 Saturation Diving Experiments

Mission	Experiment Title	Investigator
	"Reef Vegetation: Qualitative Distribution and Observations on the Influence of Fish Herbivores"	Dr. Sylvia Earle-Farlow Herbarium-Harvard University, Cambridge, Massachusetts
	"The Escape Response in Pomacentrid Coral Reef Fish"	Mrs. Ann C. Hartline, Miss Alina M. Szmant-Scripps Institute of Oceanography, University of California, San Diego
6	"Biology Studies on Benthic Cephalopods Especially Octopods"	Dr. Frederick G. Hochberg, University of California, Santa Barbara and Mr. John A. Couch - Bureau of Commercial Fisheries, Oxford, Maryland
	"Ecology, Behavior and Population Dynamics of the Spiny Lobster, <u>Panulirus argus</u>, in the Virgin Islands"	Dr. William F. Herrnkind, Florida State University, Tallahassee and Mr. Louis M. Barr-Bureau of Commercial Fisheries, Auke Bay, Alaska (continuation of 2-50)
7	"Photosynthesis in Coral-Algal Associations"	Dr. J. Morgan Wells, Jr. - Wrightsville Marine Bio-Medical Laboratory, Wilmington, North Carolina
	"Effects of Man-Made Pollution on the Dynamics of Coral Reefs"	Dr. Richard H. Chesher - Westinghouse Ocean Research Laboratory, Miami and Dr. Lawrence R. McCloskey-Marine Biological Laboratory, Woods Hole, Massachusetts
8	"Ecology, Behavior and Population Dynamics of the Spiny Lobster, <u>Panulirus argus</u>, in the Virgin Islands"	Mr. Robert Ellis-Bureau of Commercial Fisheries, Auke Bay, Alaska and Dr. Richard Cooper

Table 3 Summary of Tektite 2 Saturation Diving Experiments

Mission	Experiment Title	Investigator
		Bureau of Commercial Fisheries, West Boothbay, Maine (continuation of 2-50)
	"Algae Nitrogen Fixation Studies"	Dr. M. Heeb and Dr. C. Lee-Institute of Marine and Atmospheric Sciences, University of Miami
9	"Diurnal-Nocturnal Activity Patterns of Reef Fishes"	Mr. Bruce Collete-U.S. National Museum, Washington, D.C. and Mr. Frank Talbot, the Australian Museum, Sydney, New South Wales, Australia
	"Habitat Selection and Resource Sharing in West Indian Fish Communities"	Mr. C. Lavett Smith-The American Museum of Natural History, New York and Dr. James C. Tyler, The Academy of Natural Sciences of Philadelphia
10	"The Trophic Relations Between Coral and Sand Endofauna and Benthic Carnivores During a 24-Hour Cycle"	Dr. Jean-Georges Harmelin Marseille, France
	"Distribution of Zooplankton, Phytoplankton, Organic Detritus and Anorganic Seston in the Bottom of Lameshur Bay"	Dr. Roland vonHentig-and Dr. Wolfgang Hickel-Biologische Anstalt Helgoland, Hamburg, Germany

III

DIVING DATA

Diving times were recorded by Watch Directors on the surface. A summary of diving times was maintained by program officials but this summary did not provide all of the information required for this evaluation. Consequently, it was necessary to refer to the original logbooks which were loaned by the Tektite Program Office of the U.S. Department of the Interior. Additional information on age and weight loss was obtained from the Marine Biomedical Institute in Galveston, Texas.

The basic parameters which are employed are:

1. Mission Duration
2. Diving Time - Total
3. Diving Time - Daylight
4. Diving Time - Night
5. Diving Time - Rebreathers
6. Diving Time - SCUBA
7. Number of Dives
8. Number of Dives - Daylight
9. Number of Dives - Night
10. Number of Dives - Rebreathers
11. Number of Dives - SCUBA
12. Age
13. Weight at Start of Mission
14. Weight at End of Mission

These parameters are summarized for each of the 48 divers in Table 4. In accordance with requests by NASA, the three 20 day missions - 2, 3, and 4 - were run without a break in between. Only two engineers were used during this 60 day period and consequently each engineer stayed for 30 days and was involved in two missions. A similar pattern was employed for Missions 6, 7, and 8.

On the average, each scientist spent 187 minutes per day in the water. This represents an improvement over Tektite I which reported 108 minutes per day for each aquanaut.

Individual performances are of interest and the ten highest daily averages for in-water time are shown in Table 5.

The highest daily average belonged to a woman and commands first place by a wide margin. Interestingly, one of the Tektite II aquanauts who had been on Tektite I told a House of Representatives Subcommittee, (20) "I would liked to have been able to spend at least six hours every day in the water, but we had to change the Baralyme and cook the meals and put certain pieces of gear back together occasionally and it was just simply a matter of wanting to spend more time on the primary objectives and less time on housekeeping."

TABLE 4: Summary of Individual Diving Performance

Diver \ Measure	1. Mission Duration	2. Diving Time Total	3. Diving Time Daylight	4. Diving Time Night	5. Diving Time Rebreathers	6. Diving Time SCUBA	7. Number of Dives Total	8. Number of Dives Daylight	9. Number of Dives Night	10. Number of Dives Rebreathers	11. Number of Dives SCUBA	12. Age	13. Weight Start of Mission	14. Weight End of Mission
1. High	12	2884	2553	331	0	2884	56	50	6	0	56	37	161	161
2. Beardsley	12	2581	2319	262	0	2581	46	41	5	0	46	28	235	220
3. Curry	12	1288	895	393	0	1288	31	22	9	0	31	29	180	170
4. Dexter	12	1684	1232	452	0	1684	45	34	11	0	45	25	160	160
5. Batutis(E)	12	787	609	178	0	737	15	12	3	0	15	46	203	200
6. Koblick	20	3238	2547	691	1186	2052	51	37	14	10	41	31	163	166
7. Hunter	20	3922	3748	174	511	3411	65	63	2	5	60	35	172	170
8. Clifton	20	4063	3879	184	585	3478	68	65	3	6	62	36	165	161
9. VanDerwalker	20	3429	2560	869	933	4961	55	41	4	12	43	35	159	155
10. Kubokawa(E)	29	2738	2352	386	1094	1644	35	28	7	8	27	41	195	195
11. Phillips	19	4238	3666	572	1536	2702	40	33	7	7	33	32	148	144
12. Bowman	19	4461	3523	938	1137	3324	45	33	12	5	40	30	169	163
13. Gregory	19	4250	3700	550	480	3768	44	36	8	2	42	28	154	147
14. Birkeland	19	5976	4932	044	936	5040	60	45	15	4	56	28	159	164
15. Cooper(E)	29	1249	1134	115	202	1047	21	19	2	1	20	33	156	150
16. Mathiesen	19	1534	1493	41	0	1534	35	34	1	0	35	33	160	160
17. Bright	19	2810	1650	1160	1127	1683	33	23	10	6	27	33	184	177
18. Schroeder	19	3123	1938	1140	1335	1788	36	27	9	7	29	29	178	166
19. Fralick	19	1725	1655	70	0	1725	35	33	2	0	35	33	202	198
20. Earle	14	4888	3967	921	2729	2159	39	29	10	13	26	35	116	116
21. Hartline	14	3839	3291	548	789	3050	36	30	6	3	33	24	132	125
22. True, R.	14	2632	2189	443	1898	734	21	16	5	10	11	34	121	120
23. Szmant	14	2619	2190	429	363	2256	26	21	5	2	24	24	118	115
24. Lucas(E)	14	1526	1207	319	0	1526	16	12	4	1	15	23	120	118

TABLE 4 (Cont.): Summary of Individual Diving Performance

Measure Diver	1. Mission Duration	2. Diving Time Total	3. Diving Time Daylight	4. Diving Time Night	5. Diving Time Rebreathers	6. Diving Time SCUBA	7. Number of Dives Total	8. Number of Dives Daylight	9. Number of Dives Night	10. Number of Dives Rebreathers	11. Number of Dives SCUBA	12. Age	13. Weight Start of Mission	14. Weight End of Mission
25. Barr	21	5473	4117	1356	1715	3758	60	42	18	8	52	32	171	161
26. Herrnkind	21	4199	3237	962	1258	2941	61	47	14	12	49	30	171	167
27. Hochberg	21	5275	3578	1697	1270	4005	69	46	23	10	59	29	157	158
28. Couch	21	4039	2625	1414	718	3321	49	31	18	3	46	32	149	147
29. Heckman(E)	30	3223	2213	1010	611	2612	46	32	14	5	41	36	166	166
30. Chesher	19	4312	3204	1108	477	3835	49	34	15	3	46	30	164	155
31. Littlehales	19	2879	2042	837	0	2879	46	32	14	0	46	43	179	178
32. Wells	19	3192	2534	658	0	3192	49	38	11	0	49	30	212	204
33. McCloskey	19	3100	2483	617	472	2628	46	35	11	3	43	31	204	199
34. Atkinson(E)	30	1120	737	383	0	1120	32	24	8	0	32	27	210	218
35. Cooper	20	3621	2900	721	500	3121	56	44	12	3	53	34	179	176
36. Heeb	20	2301	2050	251	1259	1042	38	33	5	10	28	33	174	179
37. Ellis	20	3327	2664	663	490	2837	51	41	10	3	48	43	169	170
38. Lee	20	2402	2111	291	1240	1162	38	32	6	10	28	31	130	129
39. Talbot	18	2631	2320	311	1839	792	29	24	5	15	14	40	184	181
40. Collette	18	2934	2546	388	2162	722	33	29	4	18	15	36	178	177
41. Smith	18	2851	2467	384	2562	289	30	23	7	24	6	43	186	184
42. Tyler	18	3156	2661	495	2711	445	56	35	21	26	30	35	160	161
43. Marsten(E)	18	761	640	121	309	452	13	10	3	3	10	28	175	178
44. VonHentig	14	3832	2980	852	2826	1009	46	20	26	15	31	38	158	152
45. True, M.	14	1715	1257	458	0	1715	45	33	12	0	45	30	185	186
46. Harmelin	14	3511	2731	780	1898	1613	35	25	10	9	26	33	160	157
47. Nickel	14	1531	1212	319	488	1043	24	19	5	3	21	35	154	153
48. Tenney	14	1873	1429	444	646	1227	29	19	10	5	24	37	173	172

Table 5 Highest Daily Average Time in Water

	Diver	Minutes/Day	Hours/Day
1.	Earle	349.1	5.82
2.	Birkeland	298.8	4.98
3.	Hartline	274.2	4.57
4.	Von Hentig	273.7	4.56
5.	Barr	260.6	4.34
6.	Hochberg	251.2	4.18
7.	Harmelin	250.8	4.18
8.	High	240.3	4.00
9.	Chesher	226.9	3.78
10.	Bowman	223.0	3.72

Table 6 Highest Average Number of Daily Dives

	Diver	Average Dives/Day During Mission
1.	High	4.67
2.	Beardsley	3.83
3.	Dexter	3.75
4.	Clifton	3.40
5.	Hochberg	3.28
6.	Von Hentig	3.27
7.	Hunter	2.25
8.	True, M.	3.20
9.	Birkeland	3.16
10.	Tyler	3.11

Table 7 Longest Average Dive Duration

	Diver	Average Dive Duration (Min/Dive)
1.	Earle	125.3
2.	True (R)	125.3
3.	Hartline	106.6
4.	Phillips	106.0
5.	Szmant	100.7
6.	Harmelin	100.3
7.	Birkeland	99.6
8.	Bowman	99.1
9.	Gregory	96.6
10.	Lucas	95.4

On Tektite II, no one reached an average daily time of 6 hours and we can probably conclude that this is a difficult goal. Table 6 indicates the ten highest averages for number of dives. Table 7 indicates the top ten average dive durations.

Using the basic parameters of Table 4 a statistical program was run to determine means, standard deviations, standard errors and similar simple statistical descriptions. In addition, several new parameters were generated such as:

- o Number of dives per day in various categories

  day.night.Scuba.rebreather.total

- o Average dive duration in various categories

  day.night.Scuba.rebreather.total

- o Average daily diving time in various categories

  day.night.Scuba.rebreather.total

The means for each of these categories were normalized. Three separate populations were considered as follows:

1. Total Aquanaut Population (48)
2. Scientists Only (40)
3. Engineers Only (8)

The results of these analyses are shown in Appendix A - Diving Statistics.

It can be seen from data in Appendix A that the performance of aquanaut engineers is different from that of scientists. This is appropriate since their role is to free scientists from routine chores. For this reason, the engineers will be excluded from subsequent analyses.

IV

DATA ANALYSIS

Using data from Table 4 correlation coefficients were determined for 17 measures of diving performance. Results are shown in Table 8. For the sample size (40), confidence intervals of .95 and .99 are indicated by values of ρ greater than .31 and .40 respectively. For convenience Table 9 indicates only those correlations that are significant at the .95 level. Scatter diagrams for the relationships in Table 9 are contained in Ref. (23) for some of the stronger relationships.

No significant correlation was noted between length of mission and average time per day (-.15), or between average time per day and age (-.18). This agrees with findings by Helmreich (12) but it is interesting that both coefficients, while not statistically significant, are negative.

Total diving time is seen to be strongly related to rebreather diving time (.32) but even more strongly related to nightdiving (.68). Stated differently, divers who spend a lot of time diving at night, also spend more time diving than their companions. Perhaps an enthusiasm for night diving is a good indicator of an aggressive attitude toward diving in general.

Rebreather diving time is seen to be related to the number of night dives (.35), again indicating that active, aggressive divers are more inclined to use new equipment and to dive at night.

Rebreather time was significantly less for heavier divers (.52) but this conclusion is somewhat weakened by the fact that rebreathers were not available to the first mission. Individuals who had higher rebreather times had higher daily averages (.36) and the duration of their dives were longer (.53).

Night diving time is strongly correlated with the average time per day (.48) again suggesting the use of night diving experience as a performance predictor.

The total number of dives per day is inversely related to the ratio of rebreather dives to total dives (-.34). This indicates that an individual who makes a high proportion of his dives using rebreathers is apparently able to complete his work and has the need to make fewer dives.

The total number of rebreather dives is related to weight loss (.32), to age (.38) and to % weight loss per day (.32). This suggests that the use of rebreathers is associated with a higher level of activity or with increased energy expenditure.

The number of night dives is correlated with both the average time per day (.40) and the average number per day (.35).

TABLE 8: Intercorrelations Related to Diving Performance

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
1. Mission Duration (days)	1.00																
2. Total Diving Time (min)	.38	1.00															
3. Rebreather Diving Time (min)	.04	.32	1.00														
4. Night Diving Time (min)	.39	.68	.16	1.00													
5. Total Number of Dives	.47	.62	-.10	.51													
6. Number of Rebreather Dives	.14	.16	.91	.04	-.03	1.00											
7. Number of Night Dives	.20	.51	.34	.57	.47	.27	1.00										
8. Weight (lb)	.11	-.23	-.34	-.12	.18	-.18	-.04	1.00									
9. Weight Loss (lb)	.12	.03	.25	.01	.05	.32	.07	-.36	1.00								
10. Age (years)	.12	-.15	.30	-.11	.00	.38	-.01	.13	.17	1.00							
11. % Weight Loss	.11	.00	.21	.00	.08	.31	.07	-.22	.98	.18	1.00						
12. % Weight Loss Per Day	.29	.09	.23	.07	.15	.32	.09	-.24	.96	.25	.96	1.00					
13. Avg. Time Per Day(min/day)	-.15	.84	.35	.48	.38	.12	.40	-.33	-.02	-.18	-.04	-.05	1.00				
14. Avg. Number Per Day (n/day)	-.21	.36	-.17	.22	.75	-.16	.35	.19	-.06	-.06	.00	-.06	.49	1.00			
15. Avg. Time Per Dive	-.08	.53	.54	.27	-.30	.30	.07	-.53	.03	-.12	-.04	-.01	.63	-.32	1.00		
16. Ratio, Number of Rebreather Dives to Total, NR/NT	.00	-.01	.85	-.11	-.34	.92	.02	-.18	.29	.43	.28	.28	.02	-.38	.43	1.00	
17. Ratio, Time of Rebreather Use to Total, TR/TT	.12	.05	.93	-.03	-.29	.93	.16	-.27	.30	.37	.28	.28	.09	-.35	.44	.94	1.00

TABLE 9: Significant Intercorrelations Related to Diving Performance

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
1. Mission Duration (days)	1.00																
2. Total Diving Time (min)	.38	1.00															
3. Rebreather Diving Time (min)		.32	1.00														
4. Night Diving Time (min)	.39	.68		1.00													
5. Total Number of Dives	.47	.62		.51	1.00												
6. Number of Rebreather Dives			.91			1.00											
7. Number of Night Dives		.51	.34	.57	.47		1.00										
8. Weight (lb)			-.34					1.00									
9. Weight Loss (lb)						.32		-.36	1.00								
10. Age						.38				1.00							
11. % Weight Loss									.98		1.00						
12. % Weight Loss Per Day						.32			.96		.96	1.00					
13. Average Time Per Day (min/day)		.84	.36	.48	.38		.40	-.33					1.00				
14. Average Number Per Day (n/day)		.36			.75		.35						.49	1.00			
15. Average Time Per Dive		.53	.54					-.53					.63	-.32	1.00		
16. Ratio, Number of Rebreather Dives to Total			.85		-.34	.92				.43				-.38	.43	1.00	
17. Ratio, Time of Rebreather Use To Total			.93			.93				.37				-.35	.44	.94	1.00

Some of the most interesting and unexpected correlations are with aquanaut weight. Weight is negatively correlated with weight loss (-.36) indicating that with lighter divers more weight was lost. Heavier divers also spend fewer minutes per day in the water (-.33) and they spent less time on each dive (-.53). This set of relationships is one of the strongest that was found and the scatter diagrams shown in Figures 3 and 4 indicate that above the weight of 175 lbs. a diver's in-water performance is likely to be less than that of his lighter companions.

The percent of body weight that is lost is correlated to the two parameters of rebreather use, NR/NT (.43) and TR/TT (.37). A picture emerges of a smaller, more active diver who spends a higher fraction of his time using advanced equipment and consequently loses more weight.

The average number of dives per day has an inverse relationship to the time per dive (-.32) indicating that divers who made the most dives per day also made shorter dives. This fact is closely related to use of rebreathing equipment and is borne out by correlations between the average number of dives per day and the two parameters of rebreather use NR/NT (-.38) and TR/TT (-.35).

The average time per dive is also related to rebreather use parameters NR/NT (.43) and TR/TT (.44) indicating that divers who spent most time on rebreathers tended to stay out longer.

Some of the factors which may have influenced performance as subsequently analyzed are summarized in Table 10.

On the average, each diver spent approximately 2895 minutes in the water. Of this total, 2028 or 70% was spent on conventional Scuba using double tanks.* The remaining time was spent using closed cycle rebreathing equipment.

SCUBA equipment was of the standard commercially available variety using twin 72 cubic feet tanks. Normally, twin tanks are manifolded and employ single regulators but on Tektite II each tank had a separate regulator. The first tank was employed until it went "on reserve" (i.e., approximately 200 psi remained). Then the diver switched to the second tank.

One of the most significant factors in the increase of diving time noted in the Tektite II program was the use of the Mark 10 Underwater Breathing Apparatus (General Electric Company). Five units were procured by the Department of the Interior for use by program aquanauts. These units were not available for Tektite I because they were under a military security classification at the time of that program. Adverse comments about this restriction by the Navy appeared in industry publications. Subsequent testimony by Tektite I aquanauts before the House of Representative Subcommittee on Oceanography focused attention on the

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*A very small amount of time on single tanks and hookah was included with total SCUBA time to simplify calculations.

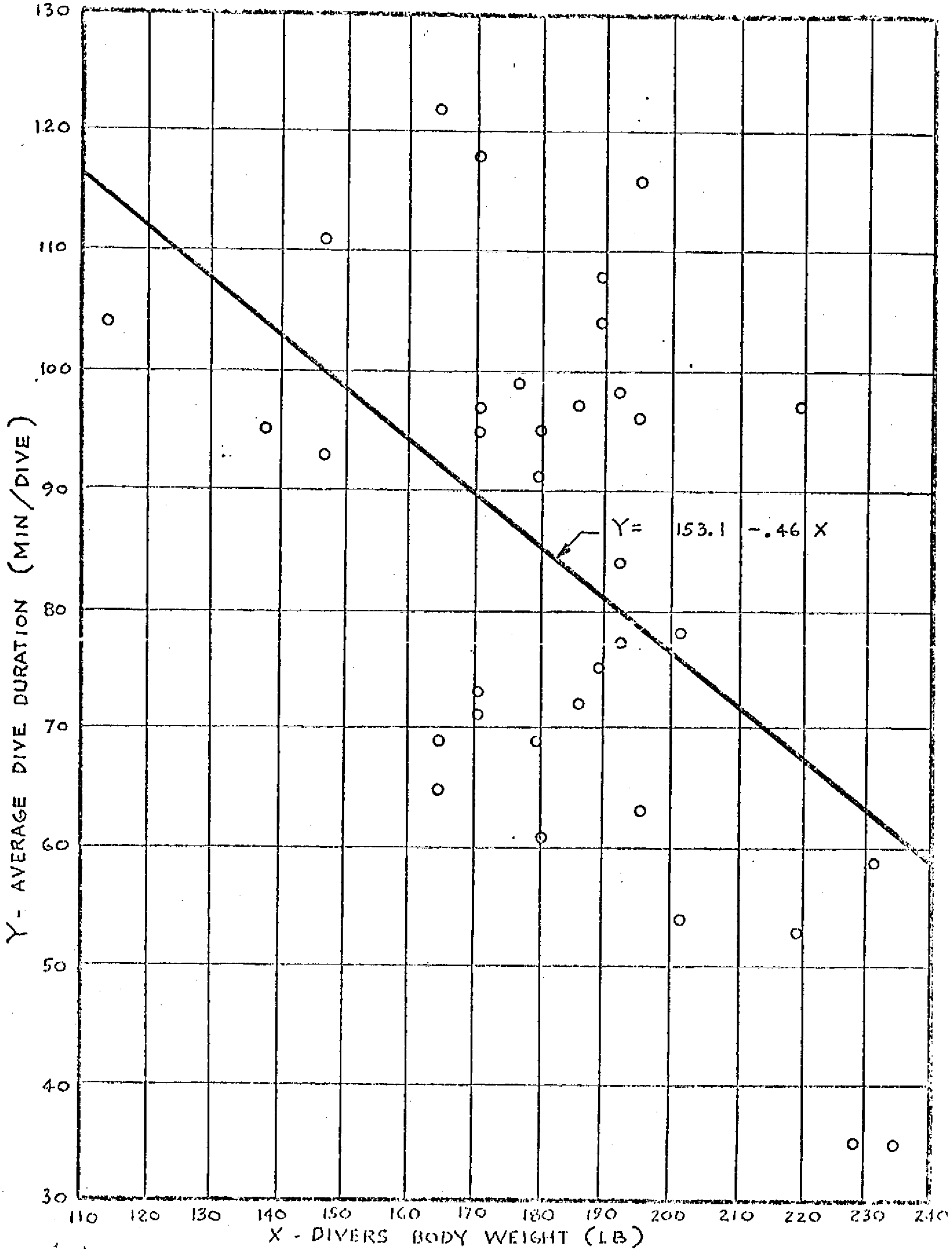


FIGURE 3: Average Dive Duration vs. Diver's Body Weight

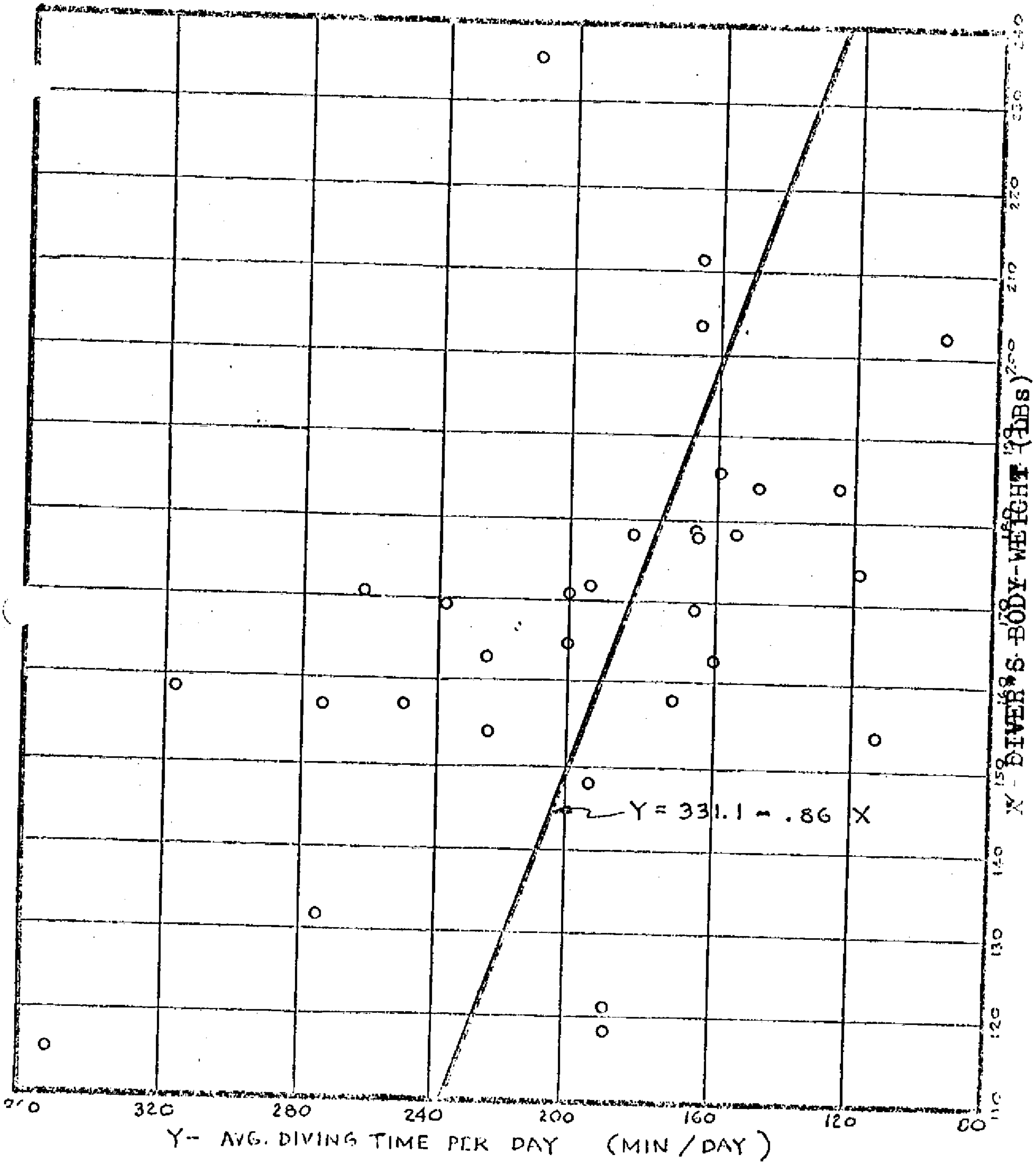


FIGURE 4: Average Diving Time per Day vs. Diver's Body Weight

TABLE 10: Factors Influencing Diving Performance

Mission	General Description	Performance	Number of Rebreather Divers	Total Duration	Lost Days Due To Severe Weather	Scientist Man-Days Lost - Sickness or Other Causes
1	Biologists Oceanographers	Active Divers	0	12	0	0
2	Biologists Geologists		4	20	0	1
3	Biologists Geologists	Active Divers	4	19	0	6
4	Biologists		2	19	0	10
5	Biologists	All Female Much Publicity	4	14	0	0
6	Biologists		4	21	0	2
7	Chemist Photographer Biologist	Virtually No Rebreather Use	0	21	2	7
8	Biologists		4	20	0	0
9	Biologists		4	18	1	6
10	Biologists Oceanographers		3	14	0	3

specific desirability of this piece of equipment, and was probably instrumental in the subsequent declassification of the device.

Two slightly different models of the Mark 10 were employed during the program. More importantly, the somewhat arbitrary operational rules concerning use of the rebreathers were changed as experience was gained. Table 11 summarizes and compares these factors. To understand the significance of the operational rules it is necessary to have an understanding of the closed cycle breathing apparatus.

The Mark 10 Mod 3 closed cycle breathing apparatus can provide life support for a diver for time periods which can reach 12 hours or for depths which may reach 1500 feet. This is accomplished by 3 basic functions.

- Sensing and maintaining the oxygen partial pressure at a preselected level
- Removing carbon dioxide exhaled by the diver from the circulating gas mixture
- Maintaining the breathing gas at the pressure of the surrounding water

A simplified schematic of this device is shown in Figure 5. General characteristics of the Mark 10 Mod 3 are given in Ref. (25). Specific details on operation and maintenance are continued in Ref. (26).

Each aquanaut-scientist was required to complete an intensive 6 day training course on the Mark 10 before the mission. This course included theory, maintenance and trouble-shooting but relied heavily on in-water training. Not all aquanauts were deemed qualified to use the device and the outstanding safety record of the program is the best testimony to the thoroughness of the instruction. A complete discussion of the formal program requirements concerning the use of the rebreather is given in Ref. (21). Some of the restrictions on the use of the equipment were somewhat arbitrary and undoubtedly tended to reflect a very conservative approach to the service life of the expendable CO_2 scrubber canisters.

CO_2 scrubber canisters are prepackaged assemblies which are discarded completely after use. Since these scrubber canisters cost approximately $30.00 each, there was a natural tendency to get full use from each canister.

The time required to disassemble and clean a rebreather varies between 20 and 30 minutes. In general it may be done alone but both set up and tear down are best accomplished by buddy teams assisting one another.

Table 12 summarizes rebreather use by various mission teams. Table 13 summarizes data on performance by individuals. As indicated, several individuals were prohibited from using the rebreather during this program. In several cases qualified users showed little inclination to use it and for obvious reasons its use was not mandatory.

Using the data of Table 13 the null hypothesis that there are no significant differences in the average number of minutes per day on rebreathers between missions was tested for nine teams.

TABLE 11: Factors Influencing Rebreather Use

		OPERATIONAL LIMITS			
Mission	Rebreather Availability	Maximum Dive Length (Hrs.)	Max. Time Allowable Time on a Canister (Hrs.)	Max. Number of Dives on a Canister (Hrs.)	Maximum Interval Between Use and Maintenance Teardown (Hrs.)
1	Not Available	-	-	-	-
2	MK10 Mod 0	4	4	1	8
3	MK10 Mod 0	4	4	1	8
4	MK10 Mod 0	4	4	1	8
5	MK10 Mod 3	4	4	1	8
6	MK10 Mod 3	4	4	1	8
7	MK10 Mod 3	4	4	1	8
8	MK10 Mod 3	4	4	1	8
9	MK10 Mod 3	4	6	2	8
10	MK10 Mod 3	4	6	2	8

SYSTEM SCHEMATIC

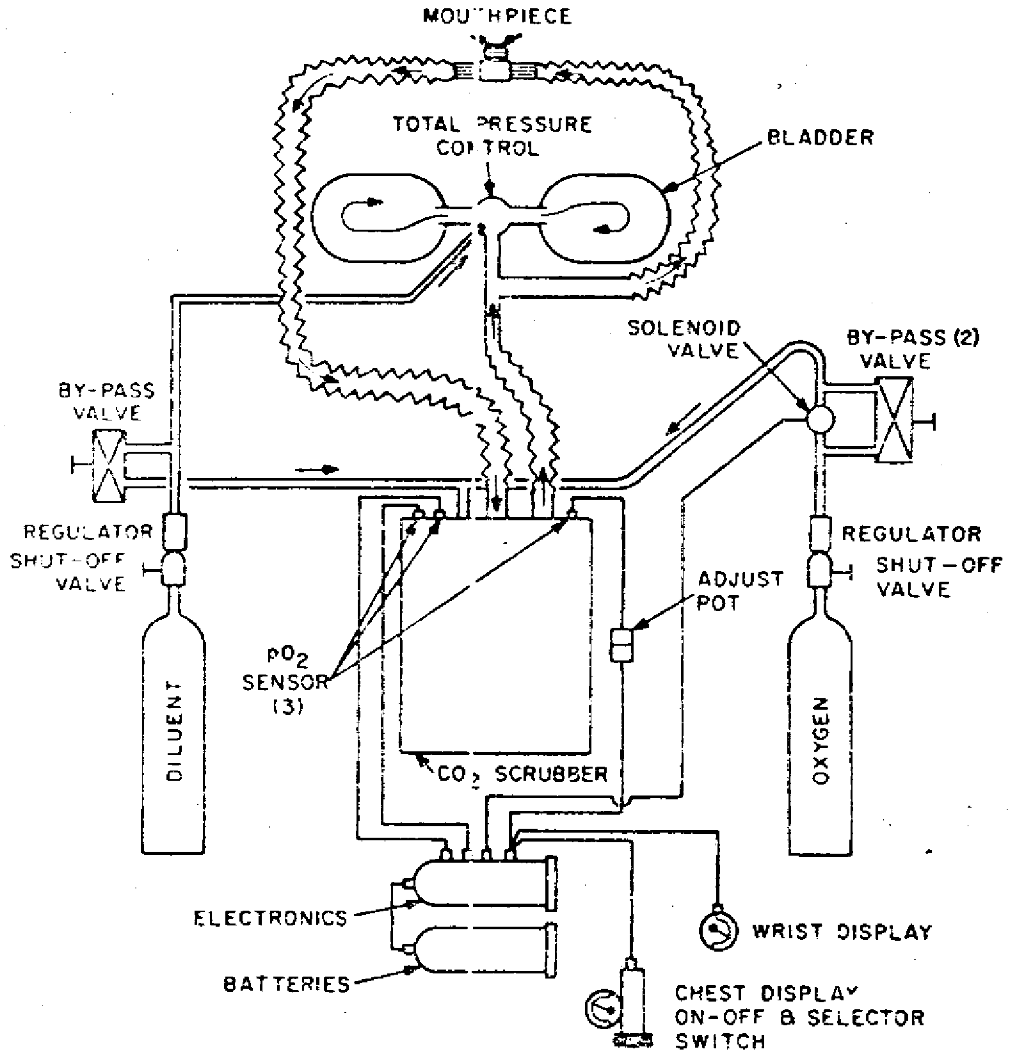


FIGURE 5: Simplified Schematic MK 10 Mod 3 Closed Cycle Rebreather

Table 12 Summary of Rebreather Use by Teams (Sceintist-Aquanauts Only)

Team	Total Rebreather Use (Minutes)	Ratio of Total Rebreather Use to Total Diving Time	Remarks
1	0	0	Rebreather not available
2	3778	.26	Used MK10Mod 0
3	4089	.21	
4	2462	.27	Only 2 Members of team qualified
5	5779	.41	Female team
6	4961	.26	
7	949	.07	Qualified team preferred to use Scuba
8	3489	.30	
9	9274	.80	
10	5212	.49	Only 3 members of teams qualified
Total	39,993	.30	

Table 13 Summary of Rebreather Use by Individuals* (Minutes)

Team Diver	1	2	3	4	5	6	7	8	9	10
A	0	1186	1536	0	2729	1715	477	500	1839	2826
B	0	511	1137	1127	789	1258	0	1259	2162	0
C	0	585	480	1335	1898	1270	0	490	2562	1898
D	0	1496	936	0	363	718	472	1240	2711	488
Total	0	3778	4089	2462	5779	4961	949	3489	9274	5212

*Scientists Only

An analysis of variance performed using these data gives the results in Table 14 and indicates rejection of the hypothesis. The test statistic if $F_{8,22} = 2.597 > 2.4$; $\alpha = .05$ which indicates that there are significant differences between missions.

Mean times for missions are ranked in Table 15. It is noteworthy that the two teams which spent the most daily time on rebreathers were those which were able to take advantage of changes in operational procedures which would permit repeated use of the rebreather canisters without disassembling the units.

Duncan's Multiple Range Test when applied to the data of Tables 13 through 15 indicates that the teams can be expected to come from a common population.

Using the normalized data of Appendix A it appears that while rebreathers accounted for approximately 30% of the total dive time on the program, only 15% of the dives were made on rebreathers. Thus, their impact on the program is seen to be substantial. Because of the interest in extending dive duration it is useful to evaluate the duration of rebreather dives. Figure 6 indicates the number of dives of various durations for Team 10. In general, rebreather dives for a period less than 1 hour would indicate an equipment malfunction. (Not necessarily the rebreather). Therefore, it appears that all aquanaut equipment functioned well for Team 10. One might have expected that one group of dives would have clustered around 4 hours and another around 2 hours. Instead, it appears that after some time in the vicinity of 3.5 hours, a diver has "had enough" and is ready to come home. This indicates strongly that the preferred pattern of use may closely resemble the pattern of work in a laboratory. Ideally, a user might prefer to eat breakfast, work for 3 to 3.5 hours, break for lunch, and again return to the water for a period of from 3 to 3.5 hours. Such a schedule would tend to fit conventional work patterns and would, simultaneously minimize the time required for preparation and recovery from diving.

The conclusion to be drawn from Figure 6 is that there is little to be gained by extending the duration of a single dive beyond 4 hours but much to be gained by establishing that rebreathers can be safely used for 2, 3 or 4 hour periods within a conventional 8 to 12 hour working day.

Table 16 summarizes the time spent on conventional SCUBA by each team and compares the ratio of SCUBA use to total diving time. Figure 7 indicates the relationship between depth and dive duration for standard SCUBA tanks. It is apparent that for slow swimming (breathing 1 ft^3 per minute) at a nominal depth of 60 feet on twin tanks, the expected dive duration will not exceed 70 minutes (e.g. 2 x 100 x .35 = 70 minutes). For 40 scientists the average SCUBA dive duration was 59.3 minutes.

Since this 59 minutes included transit time to and from the work station it is apparent that for equal time in water, fewer long duration dives are preferable.

Table 14 Analysis of Variance
(Minutes per Day, Rebreather)

Source of Variation		Sum of Squares	Mean Square	F Ratio
Between Teams	8	36956.848	4916.606	2.597
Within Teams	22	39134.871	1778.858	
Totals	30	76091.688		

Table 15 Average Time per Day on
Rebreathers by Teams (Minutes)

Rank	Team No.	Team Average
9	7	24.9
8	8	43.6
7	2	47.2
6	3	53.8
5	6	59.1
4	4	64.8
3	5	103.2
2	10	124.0
1	9	128.7

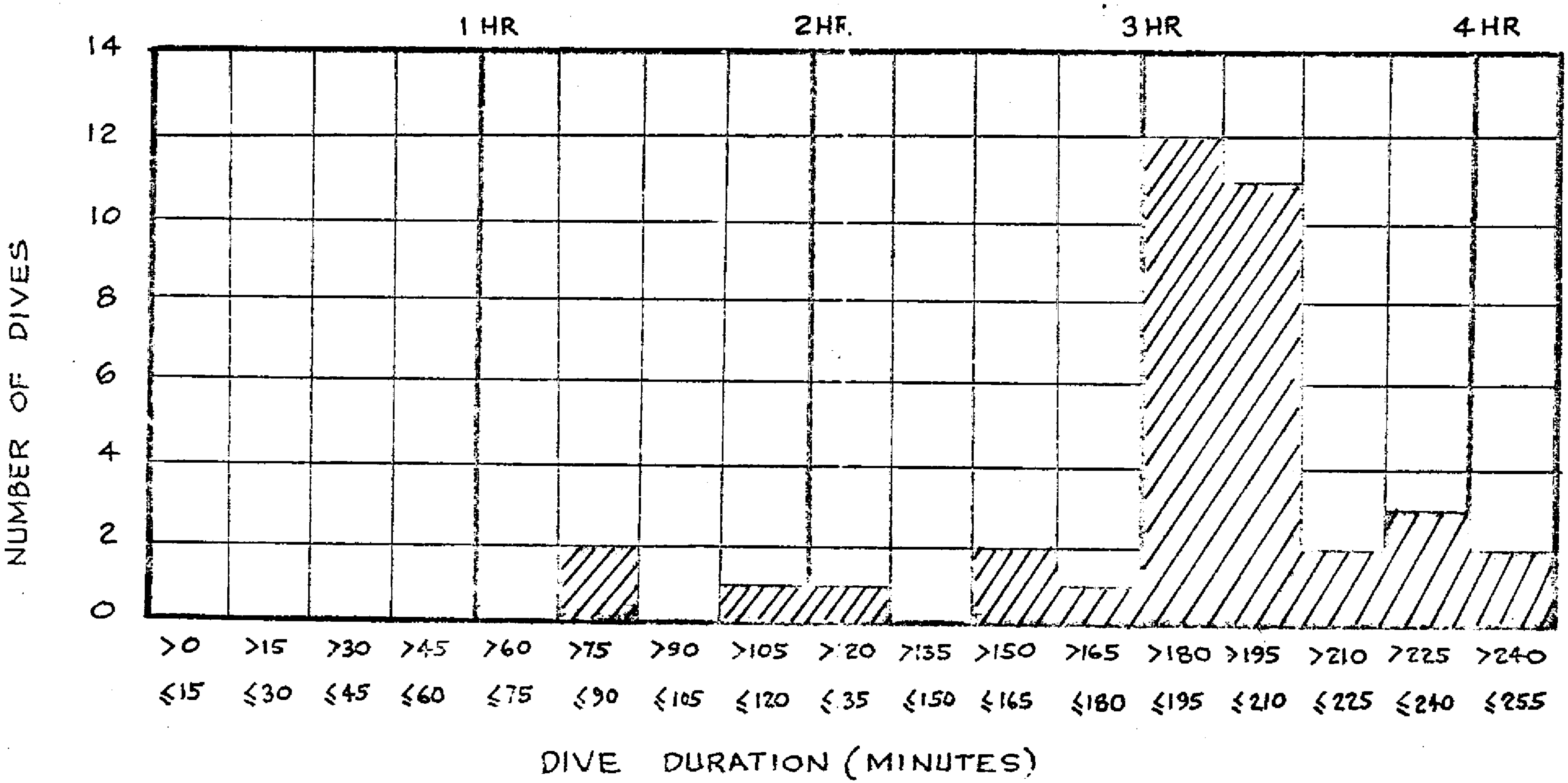


FIGURE 6: Distribution of Rebreather Dives of Varying Duration (Team 10)

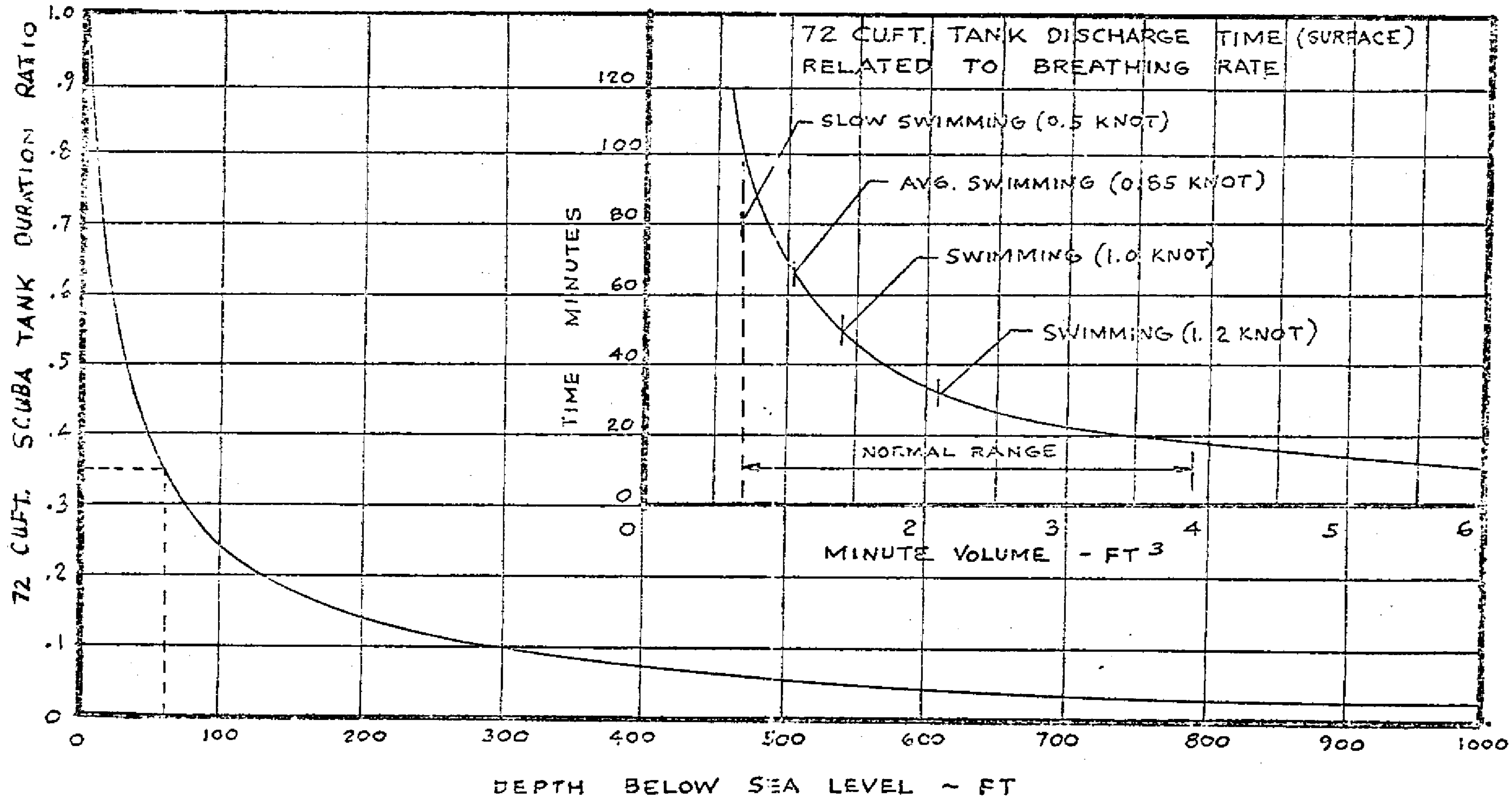


FIGURE 7: 72 Cu. Ft. SCUBA Bottle Capacity Related to Depth and Activity

Table 16 Summary of SCUBA Use by Teams*
(Scientist-Aquanauts Only)

Team	Total Scuba Use (Minutes)	Ratio of Total Scuba Use to Total Diving Time	Remarks
1	8437	1.00	Rebreather not available
2	10,874	.74	
3	14,834	.79	
4	6730	.73	2 Members could not use rebreathers
5	8199	.59	Female team
6	14,025	.74	
7	12,534	.93	Team preferred Scuba
8	8131	.70	
9	2298	.20	
10	5380	.51	1 Member could not use rebreathers
Total	91,442	.70	

*A very small amount of diving time on hookah has been included for convenience in calculations.

V

GROUP COMPARISONS

Does the burden of leadership mean that leaders have less time to spend diving or are leaders inclined to "show the way" and spend more time in the water? The role of leadership in deep habitats was explored in some detail by Helmreich (12). He concluded that "the picture of the desired leader which emerges is of an older, mature perhaps aloof man rather than someone more social, fearless and high performing." It is doubtful if these conclusions are directly applicable to shallow water saturation diving by scientists where stresses are lower, and the general maturity of all participants is high. Furthermore, Helmreich's observations were based on observations of a population in a military situation where characteristics of leadership tend to follow certain patterns. In any case, the role of leadership in Tektite II was of considerable interest to NASA since they must consider an analogous situation in space stations when crews are rotated. For this reason, in Tektite II, NASA stipulated that habitat engineers perform as crew leaders on several missions so that the effect of overlapping could be evaluated. Since engineers spend considerably less time diving, the missions where this occurred are of less interest.

On missions 1, 2, 5, 6, 9 and 10 the team leaders were scientists and the leadership role was not rotated. Using these 6 teams as a population we can determine if leaders perform differently from non-leaders. Variance ratios for 3 parameters are compared in Table 17.

For $\alpha = 0.05$, $F_{5,17} = 2.81$. Since all of the F values in Table 18 are less than 2.81, we can reject the hypotheses that performance by leaders is significantly different from non-leaders.

This conclusion seems reasonable for Tektite where the demands on the designated leaders were minimal. On other programs where water is deeper, darker or colder or where the crew members are selected on the basis of other criteria the burden of leadership may become more apparent.

More detailed studies of leadership are being made by NASA and the U.S. Navy and may add information on the role of leaders at a later date.

During the planning stages for Tektite II as the call for experiments was submitted to the marine scientific community, the question was raised-will qualified women scientists be prohibited from participation based upon their sex. Madame Cousteau had already demonstrated that a woman could successfully occupy an underwater habitat (2) and so the issue hinged very simply upon the issue of discomfort and inconvenience which would result from confining women in an enclosed space with other scientist divers. For this reason it was decided that in the event enough qualified women scientists submitted proposals that a separate all-female mission would be scheduled. This was in fact what happened and upon the acceptance of proposals by 4 female scientists it became necessary to select a female engineer.

Table 17 Variance Ratios - Parameters Indicating Effect of Leadership Role

Test Parameter	Variance (Leaders) S_1^2	Variance (Non-Leaders) S_2^2	F $\frac{S_1^2}{S_2^2}$
Minutes per Day (Average)	6431.8	2700.9	2.38
Dive per Day (Average)	.9823	.5079	1.93
Minutes per Dive	984.6	564.3	1.74

Table 18 Variance Ratios-Parameters Comparing Male and Female Performance

Test Parameter	Variance Women (S_1^2)	Variance Men (S_2^2)	F $\frac{S_1^2}{S_2^2}$
Minutes per Day (Average)	6073.0	2983.0	2.04
Dives per Day (Average	.362	.497	.73
Minutes per Dive (Average)	162.0	370.8	.44

Table 19 Comparison of Weight Change Parameters - Males and Females

		Weight Change (lb. per Individual)	% Weight Change
Scientists	Male	-3.60	-.0211
	Female	-2.75	-.0228
Engineer	Male	+ .17	+.0009
	Female	-2.0	-.0166

The concept of all female team was popular with the press and their mission received extensive press coverage both in the U.S. and overseas. The qualifications of the crew were impressive. Members of the team were:

Dr. Sylvia Earle	Research Associate in Botany, Los Angeles County Museum
Dr. Renate True	Biological Oceanographer, Tulane University
Ann Hartline	Graduate Student, Marine Ecology, Scripps Institute of Oceanography
Alina Szmant	Graduate Student, Marine Biology, Scripps Institute of Oceanography
Margaret Lucas	Graduate Student, Electrical Engineering, University of Delaware

All were qualified divers and with the exception of the habitat engineer, all had extensive open water diving experience. The mean age for the group was 29.3, slightly less than that of males, 33.1.

Performance measures by this team are summarized in Appendix A and Table 18 compares variance ratios with males. For $\alpha = 0.05$, $F_{5,17} = 2.81$. Since all of the F values in Table 18 are less than 2.81 we can reject the hypothesis that female performance, as measured by the three selected parameters, is significantly different from male performance. The performance of individual women as shown in Table 5 and 7 is, nonetheless, outstanding.

From a more subjective standpoint, a review of the program logbooks lead one to infer that the women approached their mission in an aggressive and highly competitive spirit. This is evidenced by the fact that surface watch directors kept a daily tally of cumulative dive times for females. This was rarely done on other missions and was never done as frequently or as thoroughly on other missions.

Some of the competitiveness may have been attributable to the interest inititated by journalists with recurrent questions related to the popular topics of "women's liberation" or "male chauvinism." In any case, several quotes by the team from press clippings include the following:

> "the only thing men can do down here...that we can't...is grow beards."
>
> "They (surface support personnel) were protective to the point of harrassment. They kept saying they didn't want us to hurt ourselves. They didn't think we would be able to handle our breathing tanks."
>
> "The theory that diving is for men only is a hairy-chested syndrome."

These suggest that perhaps like Avis, the female team was "trying harder."

Surface support personnel indicated a sense that the team was conscious of being in competition with male teams and were highly motivated to spend time outside. Program logs show that they did not sleep regularly. A detailed study of the use of two way closed circuit TV between the habitat and the surface noted that:

> "...the female aquanauts, as a whole, used the video phone less than any of the other teams; and they rarely used it for social purposes. Interestingly enough, they also spent more time in the water (outside the habitat) than any of the other teams, and as one of them said, she was so busy working that she had little time to talk with anyone on the surface except when absolutely necessary." (27)

Their efforts are indicated to some extent in Table 19 which compares average weight loss and percentage weight loss. As a group, the women lost the highest percentage of body weight but the values for % weight loss for males and females are strikingly close. It is apparent also that male engineers expended considerably less energy than their scientist companions. Subsequent programs might well try to correct this unbalanced condition by assigning additional work to the engineer.

In any event, if they tried harder they were successful. Based on the criteria selected as performance indicators the women performed superlatively and one must conclude that they earned a role for women participants in future shallow water diving programs.

An interesting sidelight to female participation in the Tektite Program can be taken from a recent study of male groups. (28) Tiger suggests that males aggregate in all male groups as a result of a genetically transmitted tendency to form male-male (non-erotic) bonds which are analogous to male-female bonds. He contends that this tendency dates from man's development as a hunting carnivore and has been refined by specialization and natural selection.

> "My proposition is that specialization for hunting widened the gap between the behavior of males and females. It favored those "greater packages" which arranged matters so that males hunted cooperatively in groups while females engaged in maternal and some gathering activity. Not only were there organic changes in perception, brain, size, posture, hand formation, locomotion, etc. but there were also social structural changes. The male-female link for reproductive purposes and the female-offspring link for nutritive and socialization purposes became "programmed" into the life cycle of the creatures. It is suggested here that the male-male link for hunting purposes also became "programmed" to ensure equal non-randomness in the conduct of social relationships in this matter as in reproductive ones."

This argument is buttressed by considerable data which includes the percentage of women participants in various community organizations in many nations and concludes:

> "With the exception of the USSR where 17 percent of the Supreme Soviet (which has very little power) is female, 5 percent appears to be the maximum of female participation in various parliaments. It is a maximum seldom attained; Netherlands - 5 to 6 percent; French Assembly - 3.6 percent; Norway - 4 percent; U.K. - 3 percent; United States Congress - 2 percent.
>
> In the local and municipal bodies, the proportion is seldom higher and often lower...At the governmental level, women play an even smaller part."

From these types of considerations, one might be led to conclude that for reasons unrelated to ability, women are not likely to play an increasingly large role and on programs involving more uncertainty or danger, their role could possibly decrease or disappear. This is perhaps an unfortunate and reluctant conclusion in view of performance. Based upon Tektite II performance data, qualified women scientists belong in subsequent shallow water programs.

VI

NIGHT DIVING PERFORMANCE

During the program, a total of approximately 381 night dives were made by scientists. This number is called "approximate" because there is no precise demarkation between day and night. In order to separate all diving activities into day or night categories a night dive was defined to be one which started after sunset, or ended before sunrise. Several scientists had a particular interest in crepuscular activity and these cases were treated as daylight dives. There were very few long duration dives which spanned the period from full daylight to full darkness. Allowance was made for changes in the time of sunrise and sunset during the program but variations in light due to bad weather, overcast or haze was not considered.

Night diving differs from daylight diving in that it is more hazardous. It is more difficult to maintain visual contact with companion divers and it is harder to recognize surrounding terrain features. The use of flashlights and emergency signal lights is mandatory. Operating procedures required night divers to carry two emergency lights (battery powered xenon flashers). One was attached to the diver and the other to a tethered balloon which could be released to the surface.

At night when they are most difficult to see, the long spined sea urchins (diadema) leave their crevices to feed and the likelihood of a painful encounter is greatly increased. However, night diving on Tektite was similar to night diving anywhere in that the worst dangers are not from marine predators. In summarizing a summer of night diving Schroeder states (29):

> "None of our real emergencies involved dangerous animals. As in daylight diving, all our troubles resulted from equipment failures or carelessness."

The duties of safety divers at night are more demanding. Reduced visibility hampers the operation of small craft and makes diving from the surface more hazardous. For night dives to be made, a full 3-shift operation of safety divers must be maintained.

One purpose in carefully evaluating the role of night diving is to assess potential economies which might result from limiting or restricting night diving. The idea is not to limit or restrict opportunities for scientists to dive and work at night but rather to direct the patterns of night diving in order to obtain overall program economies. These economies can be determined if it is possible to reduce the size of a shift during any eight hour period in which it is known that no diving will occur.

Statistical data on night diving is summarized in Table 20. The Watch Directors Logbooks reveal a wide degree of variability in range, duration and number of

Table 20 Summary of Average Duration of Night Dives Within a 24 Hour Period (Minutes Per Day)*

Team Individual	1	2	3	4	5	6	7	8	9	10
A	27.6	34.6	30.1	2.1	65.8	64.6	58.3	36.1	17.3	60.8
B	21.8	8.7	49.4	61.1	39.1	45.8	44.1	12.1	21.6	32.7
C	32.7	9.2	28.9	60.0	31.6	80.8	34.6	33.2	21.3	55.7
D	37.7	43.5	54.9	3.7	30.6	67.3	32.5	14.6	27.5	22.8
Team Mean	30.0	24.0	40.8	31.7	41.8	64.6	42.4	24.1	21.9	43.0

*Scientist Only

Table 21 Analysis of Variance (Minutes per Day, Night Diving)

Source of Variation	df	Sum of Squares	Mean Square	F Ratio
Between Teams	9	6007.148	667.461	2.417
Within Teams	30	8284.555	267.152	

Table 22 Average Time Per Day Spent Night Diving by Teams (Minutes)

Rank	Team Number	Team Average
10	9	21.9
9	2	24.0
8	8	24.1
7	1	29.9
6	4	31.7
5	3	40.8
4	5	41.8
3	7	42.4
2	10	43.0
1	6	64.6

dives between individuals. For example, there are several cases when individuals made frequent night dives at intervals of 30 minutes for durations of 2 to 3 minutes. These dives were typically made for serial observations or serial sampling and could only be performed on one or two nights. Dr. James Tyler, icthyologist, described his activities this way:

> "Two nights in a row I went out every hour to check a sponge on a reef in front of the habitat. It only took me a minute to look inside, to see if a sponge dwelling fish was there and note what the fish was doing. In between sponge checks every 60 minutes all night, I drank coffee to stay awake and watched the tarpon swirling through a graceful arc around the habitat occasionally snapping at little fishes. (30)

Other dives were made for long durations and to considerable distances from the habitat.

Using the data in Table 20 we can test the hypothesis that there is no significant difference in night diving between teams. The results of an Analysis of Variance are given in Table 21 and indicates that the hypothesis should be rejected. The test statistic is $F_{9,30} = 2.42 > 2.21$; $\alpha = .05$. Table 22 summarizes and ranks teams with regard to night diving.

To determine which teams could come from a common population the data in Table 20 was used to perform Duncan's Multiple Range Test. The results indicate that Team 6 differed greatly from the common population in the amount of night diving. Team 6 was the most active. When we consider the experiments conducted by members of Team 6, (see Table 3) this is not surprising since octopods are nocturnal.

From the foregoing, it can be inferred that the teams which did the heaviest night diving knew of their intention well in advance of their mission.

It is likely that a survey taken prior to the start of the program would have revealed those individuals who would require the heaviest schedule of night diving. These individuals could have been scheduled together. On subsequent programs individuals requiring few night dives could be teamed in such a way that the burden of surface support could be reduced.

The logbook indicates variability in the patterns of night diving. Some teams completed their night dives shortly after midnight. Others were awakened in the early morning hours to begin diving. Where such patterns occur near the time of a regularly scheduled shift change (e.g., midnight), a slight shifting of dive schedules might greatly facilitate the role of surface support.

While no attempts should be made to reduce or restrict night diving, it is reasonable to specify conditions on diving. For example, during a two week mission, night dives between 0030 and 0830 (a typical third shift schedule) could be restricted to the second week of the mission. If such a limitation could be used to effect a reduction in the total number of surface personnel required, then it would have a significant influence on total program cost. Careful planning based on factors such as these will be required to reduce the number of support personnel required and to make scientific saturation diving more efficient.

VII

SWIMMER MOVEMENT

It is interesting to consider the distances traveled underwater by diver scientists in the performance of their tasks. An analysis of typical excursions may be useful to future missions planners since the Marine Science Council (10) has stated that "swimming is a very inefficient method of propulsion and small propulsion units are required for certain jobs." In testimony before a House Subcommittee, Tektite I aquanauts stated that after closed circuit breathing devices, the most needed item was "swimmer propulsion units for transporting devices from place to place on the sea floor." (20)

Determination of excursion distances during Tektite II is complicated by the fact that:

1. distances are only determined from dive plans reported to the surface in advance of the dive
2. divers often change their plans and
3. divers often tend to overestimate in their planning.

Nevertheless, the information provided by diving logs provides general guidelines to excursions from the habitat. Figure 8 shows the Tektite II site but excludes the grid which was used by surface support personnel. The chart was prepared by Dr. H.E. Clifton of the U.S. Geological Survey and is shown in Ref. (18).

Grid spacing intervals are 100 feet. Using the diving logs, Missions 9 and 10 were selected arbitrarily and the number of diver visits to various zones was tabulated. Results of these tabulations are given in Figure 9 and 10. It can be determined that most dives are made to relatively short distances from the habitat. Table 23 summarizes ranging activity. Data from other missions does not appear to differ substantially from that for Teams 9 and 10.

These relatively short distances are not the result of limited duration capability of equipment. As shown in Appendix A, the mean duration for all scientific dives was 75.7 minutes. Reference (31) determined that divers can sustain a mean velocity of 1.1 mph over distances of 1/2 mile. Thus it appears that the excursions on Tektite reflected the needs and requirements of the diving scientists rather than a restriction imposed by breathing devices.

It should be noted that Tektite II was conducted in calm, warm, clear water where conditions are nearly optimal for safe, comfortable diving. On other saturation programs in colder, deeper or more turbid waters it is unlikely that greater excursion distances will be encountered at least not until there have been significant breakthroughs in homing devices and safety equipment. For this reason, information in Table 23 should suggest that in the subsequent procurement of swimmer propulsion aids for scientists working from habitats, primary emphasis should not be placed on extended range or on extended duration but on other

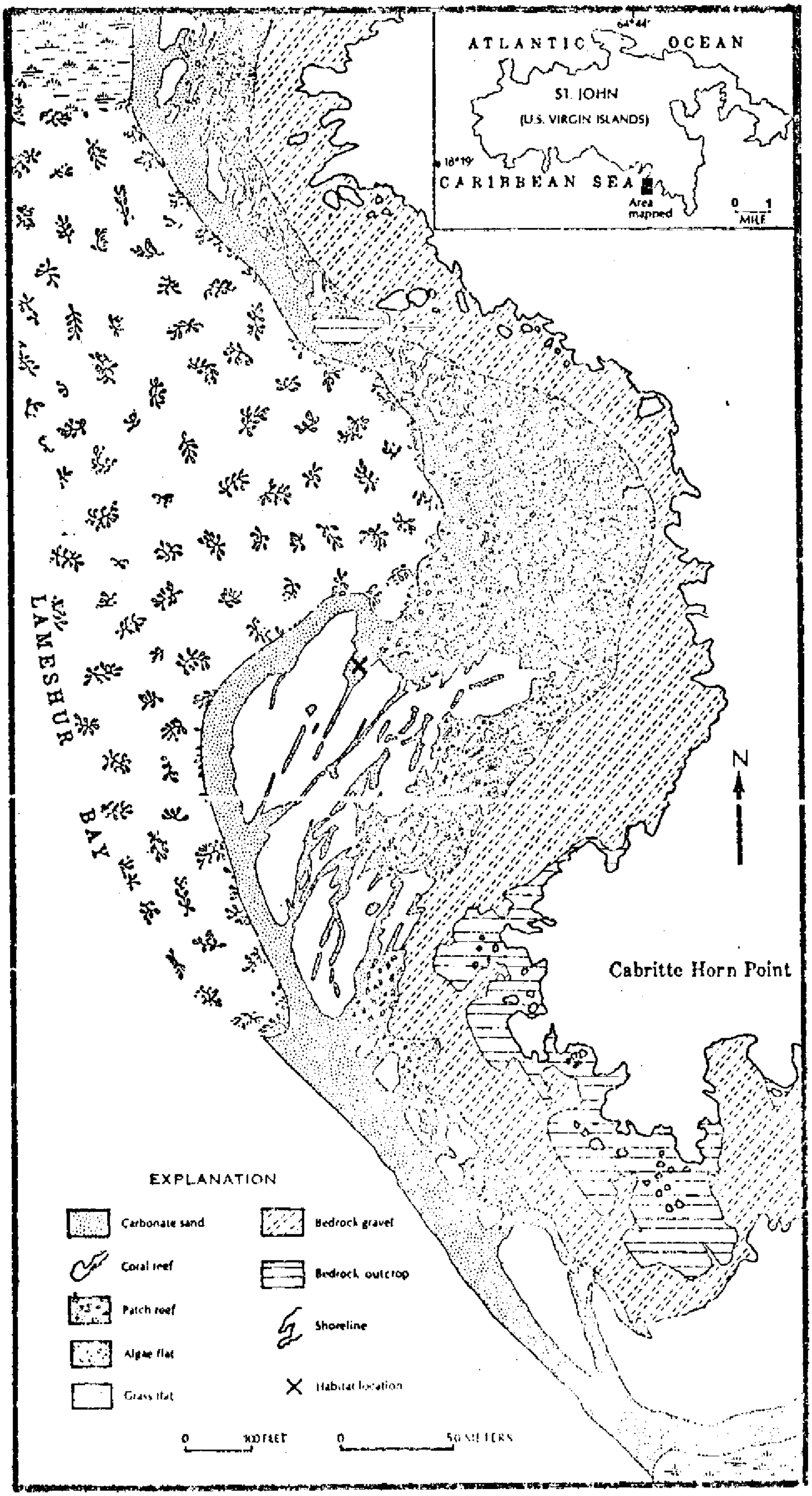
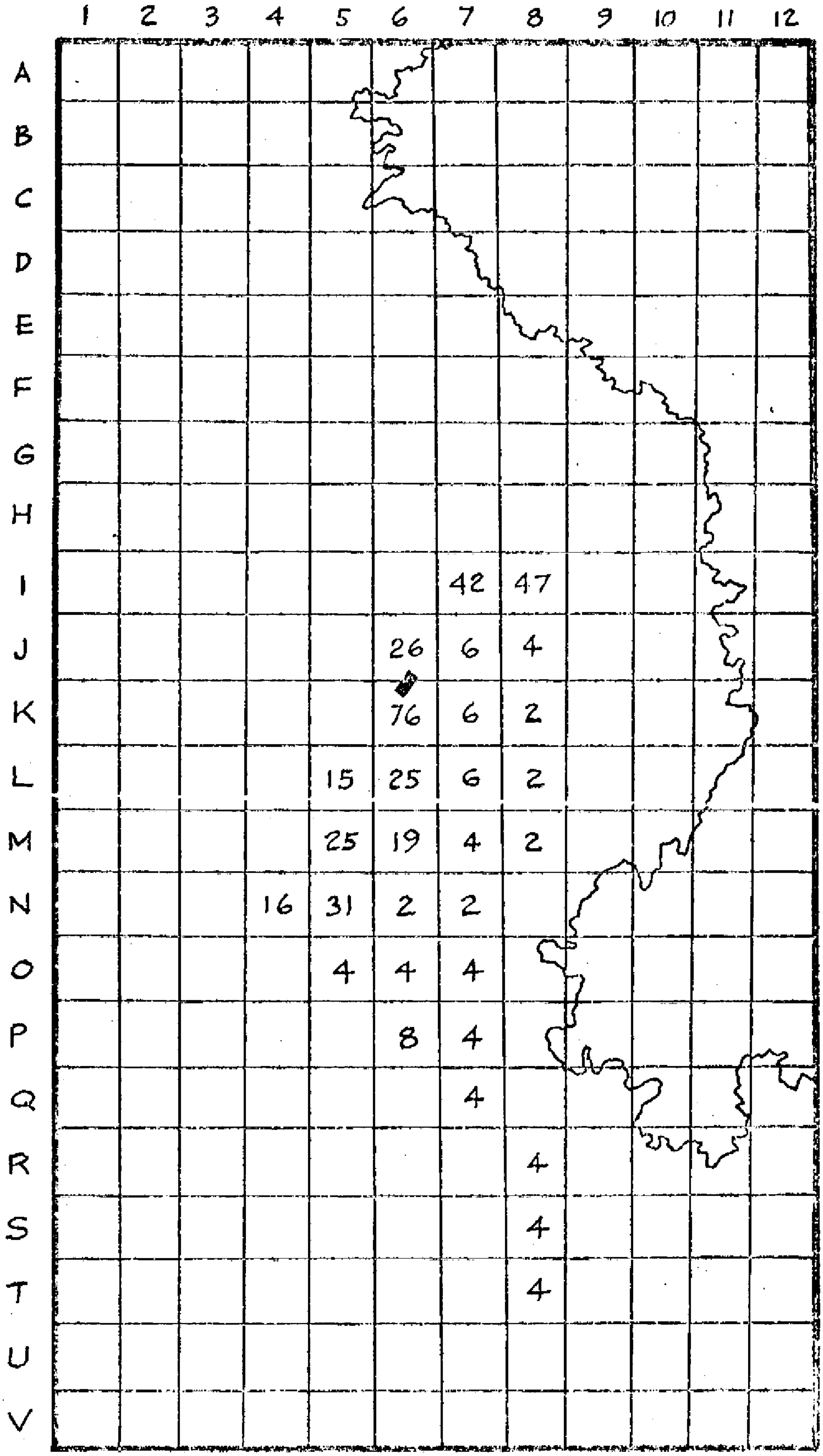
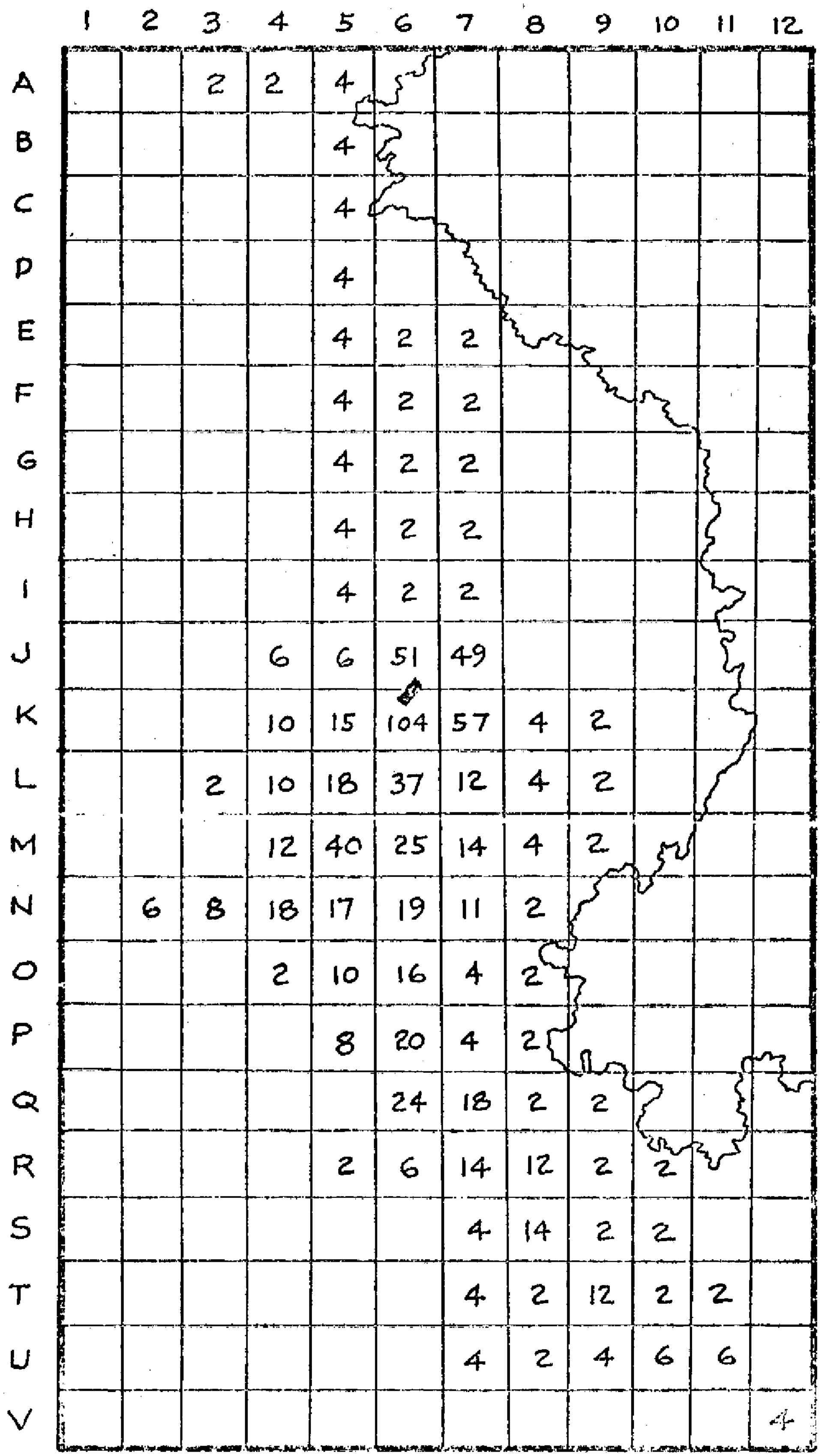


FIGURE 8: Tektite II Site



	1	2	3	4	5	6	7	8	9	10	11	12
A												
B												
C												
D												
E												
F												
G												
H												
I							42	47				
J						26	6	4				
K						76	6	2				
L					15	25	6	2				
M					25	19	4	2				
N				16	31	2	2					
O					4	4	4					
P						8	4					
Q							4					
R								4				
S								4				
T								4				
U												
V												

FIGURE 9: Frequency of Excursions to Various Zones (Team 9)
(Grid Intervals - 100 Feet)



	1	2	3	4	5	6	7	8	9	10	11	12
A			2	2	4							
B					4							
C					4							
D					4							
E					4	2	2					
F					4	2	2					
G					4	2	2					
H					4	2	2					
I					4	2	2					
J				6	6	51	49					
K				10	15	104	57	4	2			
L			2	10	18	37	12	4	2			
M				12	40	25	14	4	2			
N		6	8	18	17	19	11	2				
O				2	10	16	4	2				
P					8	20	4	2				
Q						24	18	2	2			
R					2	6	14	12	2	2		
S							4	14	2	2		
T							4	2	12	2	2	
U							4	2	4	6	6	
V												4

FIGURE 10: Frequency of Excursions to Various Zones (Team 10)
(Grid Intervals - 100 Feet)

Table 23 Typical Excursion Distances - Teams 9 and 10

Distance (Yards)	% of Visits to Site in Varying Range Brackets to Total Visits Team 9	Team 10
0-100 yards	76.6	56.4
0-200 yards	96.0	79.5
0-300 yards	99.5	93.0
0-400 yards	100.0	99.6
400 yards	-	100.0

parameters such as reliability or ease of maintenance.

In his "Quick Look" Report to the Department of Interior, Georges Harmelin (Team 10) stated

> "I spent, for my part, 4 to 6 hours in the water each day. For an average of 5 hours, the division of my dive time was generally as follows:
>
> 1 1/2 hours: effective work at my station
> 1 hour: accompanying one of the crew during his work
> 2 1/2 hours: travel to the place of work, general biological observations underwater photography..."

Thus, perhaps 50% of total time in the water may be required for travel to and from work stations. The case for swimmer propulsion aids is strong.

VII

MULTIPLE DIVES

One of the expected results of this study was a dramatic difference in performance between users of rebreathers and users of SCUBA. The reason for the absence of such a sharp difference is not immediately apparent. One possible answer may be that the greatly improved "efficiency" of the rebreathers allows the scientist to spend more time on station for less total time in the water. A diver relying on rebreathers and making a few long dives, will spend more time at his work station than a diver who spends the same time in the water but who makes shorter, more frequent dives. This is difficult to demonstrate quantitatively but can easily be proved by inference.

During the Tektite I Program, an attempt was made to determine the time required to prepare for a dive and to recover from the dive after returning to the habitat. These times were determined for each diver by a surface observer who recorded information according to the legend which is shown in Table 24. Thus, available records show, with considerable precision, the time spent before and after dives. The sum of these times can be considered as the "equipment penalty" and is independent of the time spent in the water. Data for all of the dives on Tektite I is summarized in Table 25. From this table it can be seen that a typical dive requires approximately 16 minutes of preparation and 9 or 10 minutes for recovery. If we select an "equipment penalty time" of 25 minutes and apply this penalty to the number of daily dives made by individuals described in Table 6, we obtain the results shown in Table 26. This table indicates that the time spent preparing and recovering from dives is considerable and will substantially influence the time available for diving. It also indicates clearly the advantage of improving "in water" time by making fewer dives of longer duration. This penalty is graphically demonstrated in Figure 11. A scatter diagram relates Average Dive Duration (minutes) and Average Number of Daily Dives for Tektite II scientists. The product of these numbers is the average daily diving time. Lines of constant daily dive time appear as hyperbolas and are shown for several values. It can be seen that the outer envelope of the points define a performance boundary. Points along this boundary correspond to the best performance by individual divers. This does not suggest that the points define the limits of capability or endurance but they do define a limit for practically realizable performance over a sustained period.

The curve of best fit for this boundary may have considerable practical significance and is given by an asymptotic expression of the form $Y = \phi + \beta \rho^{x}$. The resulting coefficients are $\phi = 44.1$

$\beta = 33.0$

$\rho = 0.56$

For practical purposes a simple parabola is accurate for $1 < N < 4$ and is given by:

$$Y = 32.7\,x^{2} - 283.0x + 659.2 \qquad (1)$$

Table 24 Legend for Dive Record - Tektite I Program

1. Date
2. Diver identification.
3. Time preparations for dive were started.
4. Time preparations for dive were completed.
5. Time at which diver entered water.
6. Time at which diver reentered habitat.
7. Time at which diver began to remove gear.
8. Time at which gear storage was completed.
9. Time diver entered desalinization shower.
10. Time diver completed desalinization shower.

Table 25 Average Preparation and Recovery Time for Dives during Tektite I

	Dive Preparation Time (Min)		Dive Recovery Time (Min)	
	Mean	Std Dev	Mean	Std Dev
Diver 1	16.7	9.7	6.5	5.5
Diver 2	17.5	10.0	13.2	11.1
Diver 3	16.5	10.8	11.4	9.8
Diver 4	17.1	11.4	9.0	7.8

Table 26 Typical Daily Diving "Equipment Penalties" for Active Divers-Tektite 2

Diver	Average Dives Per Day During Mission	Daily "Equipment Penalty"(min.)
1	4.67	117
2	3.83	96
3	3.75	94
4	3.40	85
5	3.28	82
6	3.27	82
7	3.25	81
8	3.20	80
9	3.16	78
10	3.11	73

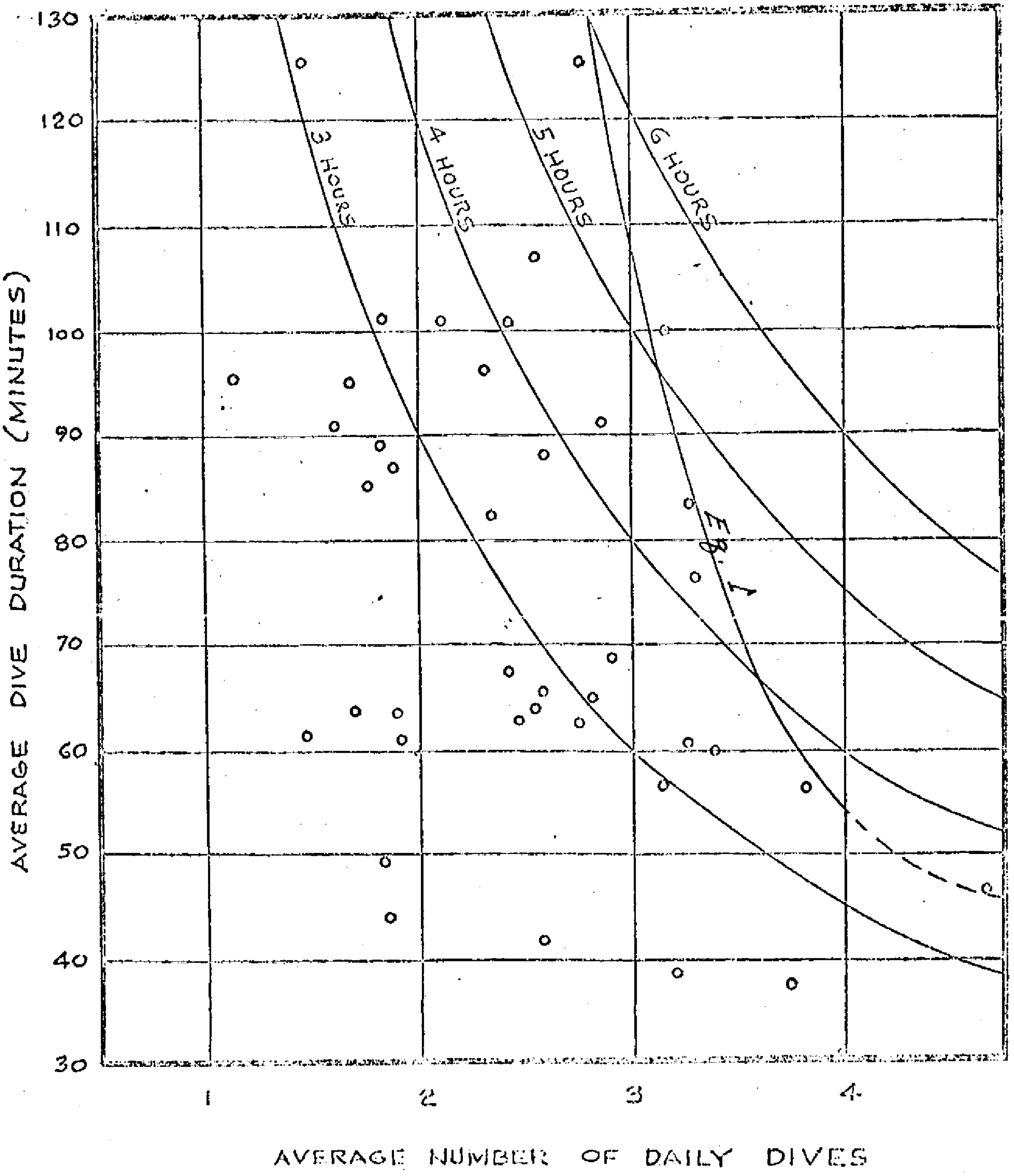


FIGURE 11: Average Dive Duration vs. Number of Dives (Scientists Only)

which is superimposed on Figure 11. It is obvious that a swimmer who wants to improve his daily average time is well advised to make fewer, long dives rather than more short dives.

Table 27 summarizes the average number of dives per day by individuals and by teams. Table 28 indicates the results of an Analysis of Variance for performance between teams and indicates that there are highly significant differences between teams. Table 29 ranks teams relative to the average number of daily dives. Duncan's Multiple Range Tests applied to the data in Table 27 indicates that all teams could be expected to come from a homogeneous subset except Team 1, the team which did not have the opportunity to use rebreathers.

Perhaps the best testimony to the advantage of rebreathers for saturation diving is given by the scientists who used them. The following paragraphs typify comments by users.

> "The ability to leave the habitat at will any time of the day or night provided the freedom necessary for effective observation of the behavior of our subjects in relation to sound production. Bubbles produced by open circuit diving gear hampered our attempts to observe organisms while using it. Not only did the bubbles create a great deal of noise but they frightened the subjects to the point of appreciably altering their behavior. We, therefore, customarily used open circuit apparatus while performing work tasks not directly associated with behavioral observations. Never the less, we did obtain a significant amount of data while using the SCUBA units.
>
> The rebreather units were unavailable to us during the observational periods indicated above. Their low noise level and lack of bubbles allowed us to approach the subjects, very closely without interfering with the organisms normal behavior pattern or with the recordings we were making. At times while wearing the rebreather and remaining quite still we were treated as a portion of the substrate. With the rebreather on we found that after a short while we were able to detect, with the unaided ear, both the background noises and the sounds produced by fishes and certain invertebrates..."

In any event, rebreathers can and do improve performance by reducing the need for time-wasting, multiple dives.

Table 27 Summary of Average Number of Dives per Day*

Individual \ Team	1	2	3	4	5	6	7	8	9	10
A	4.67	2.55	2.11	1.84	2.77	2.86	2.58	2.80	1.61	3.27
B	3.83	3.25	2.37	1.74	2.56	2.90	2.42	1.90	1.83	3.20
C	2.58	3.40	2.32	1.89	1.49	3.28	2.58	2.55	1.67	2.49
D	3.75	2.75	3.16	1.84	1.85	2.33	2.42	1.90	3.11	1.70
Team Mean	3.71	2.99	2.49	1.83	2.17	2.84	2.50	2.29	2.06	2.67

*Scientists Only

Table 28 Analysis of Variance (Average Number of Dives per Day)

Source of Variation	df	Sum of Squares	Mean Square	F Ratio
Between Teams	9	10.473	1.164	4.029
Within Teams	30	8.666	.289	
Total	39	19.139		

Table 29 Average Number of Dives per Day by Teams

Rank	Team Number	Team Average
10	4	1.83
9	9	2.06
8	5	2.17
7	8	2.29
6	3	2.49
5	7	2.50
4	10	2.67
3	6	2.84
2	2	2.99
1	1	3.71

VIII

CONCLUSIONS AND RECOMMENDATIONS

Based on the foregoing analyses these conclusions can be made.

Rebreather Use

1. The use of rebreathers is a highly significant factor in improving performance by permitting long duration dives to be made.
2. Teams making the greatest use of rebreathers tended to make fewer dives than others but these dives were for longer durations and hence were more efficient.
3. Individuals making most use of rebreathers tended to experience greater percent weight loss per day.

Night Diving

4. Divers who dive a lot at night tend to dive more at all times than those who do not.
5. Divers who dive more at night tend to use rebreathing equipment more often than those who do not.

Female Performance

6. Overall performance by females was outstanding in all categories.

Leadership Responsibilities

7. Leaders do not perform significantly different than non-leaders on any of the most important measures of diving performance.

Role of Weight

8. Heavy divers spend less time diving than lighter divers.

9. Heavy divers usually make shorter dives than lighter divers.

10. Heavy divers lose less weight during missions than lighter divers.

Age

11. Age is not related to diving performance.

In the course of carefully reviewing the Tektite Program Watch Directors Logbooks and in discussions with program management, several areas for improvement were noted and these are given here. These recommendations do not, in many cases, follow as a result of the analyses but rather from a careful reading of program records. The author was privileged to act as habitat engineer (Team 10) during Tektite II and can evaluate logbook entries based on first hand knowledge of field conditions. Since these observations may be of use to subsequent program planners they are considered appropriate for inclusion.

1. Subsequent programs should consider the use of designed experiments to provide information on diving performance.
2. Subsequent programs should employ a formatted data sheet to assist watch directors in keeping accurate and complete diving records.
3. Consideration should be given to the use of "porta punch" devices to permit data cards to be prepared immediately and inexpensively.

These devices were used to record behavioral data and their use should be extended to official program diving records.

4. Format sheets should discriminate between dives using single and double tanks and between various types of insulated garments.
5. Establish groundrules for scoring dives and train Watch Directors in their use.
6. Make use of ear prophylaxis mandatory. Lost days should be minimized by whatever techniques are most effective. Virtually all of the days lost to illness were directly or indirectly related to ear problems.
7. A sufficient quantity of rebreathers should be procured and their use should be strongly encouraged. If necessary, program schedules should be delayed slightly if necessary to complete rebreather qualification training.
8. Careful consideration should be given to the possible economies which would result from reducing watch crews at night by placing conditions on night diving.
9. Consideration should be given to the use of previous night diving experience as a determinant in crew selection where all other factors are equal.
10. Measures should be taken to prevent the inadvertent interchange of rebreather covers. This makes trouble-shooting from the surface difficult and dangerous since the identity of the devices becomes open to question.
11. Periodic checks of Watch Director Logs should be made by key project personnel in order to correct problems as they arise. The following log notation was not resolved.

    > "Just wondering - are W.D.'s (Watch Directors) making a <u>post</u> dive check of rebreathers with aquanauts - I have not been and according to <u>recent</u> log entries neither has anybody else."

12. Instructions in log maintenance should be standardized to prevent ambiguities or omissions.
13. The role of female aquanauts should be expanded in subsequent programs.
14. Consideration should be given to the use of weight as a determinant in crew selection where all other factors are equal.

As the scientific community becomes increasingly aware of saturation diving, its use will grow rapidly. At the present time plans for saturation facilities are under consideration in the Caribbean, the Gulf of Mexico, the Great Lakes and the Pacific Northwest. Japan is constructing a saturation system and Germany is reconditioning "Helgoland" for a new program. But the key to steady, successful progress lies in the performance of the using scientists. And their success is tied to improvements in efficiency and effectiveness in daily work. The analyses described here may help to provide a key to improved performance from saturation habitats.

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APPENDIX A - Diving Statistics

A1 - Total Tektite 2 Scientific Program

A2 - Scientists

A3 - Engineers

A4 - Female Scientists

A5 - Male Scientists

A6 - Male Engineers

A7 - Rebreather Users

A8 - Non-Rebreather Users

A9 - Team Leaders

A10 - Non-Leaders

VAR NO	MEAN	S.D.	S.E. OF MEAN	SAMPLE	MAXIMUM	MINIMUM	RANGE	VARIABLE
1	18.3332	4.4832	0.6471	48	30.0000	12.0000	18.0000	MISSION DAYS
2	3015.4558	1233.1738	177.9933	48	5976.0000	761.0000	5215.0000	T TOTAL DIVE TIME (MIN)
3	2112.5183	1130.9155	163.2336	48	5040.0000	289.0000	4751.0000	T_S TOTAL, SCUBA (MIN)
4	1202.5535	754.7148	125.7858	36	2826.0000	202.0000	2624.0000	T_R TOTAL, REBREATH. (MIN)
5	2416.9138	998.5837	144.1331	48	4932.0000	609.0000	4323.0000	T_D TOTAL, DAYLIGHT (MIN
6	631.2688	411.4006	59.3806	48	1746.0000	41.0000	1705.0000	T_N TOTAL, NIGHT (MIN
7	41.3332	13.8261	1.9956	48	69.0000	13.0000	56.0000	NUMBER OF DIVES, TOTAL
8	35.2915	14.4280	2.0825	48	62.0000	6.0000	56.0000	NUMBER, SCUBA
9	7.8378	5.9792	0.9830	37	26.0000	1.0000	25.0000	NUMBER, REBREATHER
10	31.7082	11.5167	1.6623	48	65.0000	10.0000	55.0000	NUMBER, DAYLIGHT
11	9.4167	5.7049	0.8234	48	26.0000	1.0000	25.0000	NUMBER, NIGHT
12	169.6326	69.6196	10.0487	48	349.1428	37.3333	311.8093	AVG MIN PER DAY - TOTAL
13	118.6430	62.4048	9.0074	48	265.2629	16.0555	249.2074	AVG. MIN PER DAY - SCUBA
14	47.9119	50.1473	8.3579	36	201.8571	6.9655	194.8916	AVG MIN PER DAY - RBTH
15	136.3615	58.2039	8.4010	48	283.3569	24.5667	258.7900	AVG MIN PER DAY - DAYLIGH
16	34.9084	20.4813	2.9562	48	87.3000	2.1579	85.1421	AVG MIN PER DAY, NIGHT
17	2.3322	0.8311	0.1200	48	4.6667	0.7222	3.9444	$\bar{N}$ AVG. NUMBER PER DAY, TOTA
18	1.9972	0.8967	0.1294	48	4.6667	0.3333	4.3333	$\bar{N}$, SCUBA
19	0.4346	0.3517	0.0578	37	1.4444	0.0345	1.4100	$\bar{N}$, REBREATHER
20	1.7890	0.7072	0.1021	48	4.1667	0.5556	3.6111	$\bar{N}$, DAYLIGHT
21	0.5327	0.3333	0.0481	48	1.8571	0.0526	1.8045	$\bar{N}$, NIGHT
22	73.6086	22.2549	3.2122	48	125.3333	35.0000	90.3333	$\bar{T}$ AVG DIVE DURATION, TOTAL
23	→ 59.0869	18.3907	2.6545	48	101.7333	14.8333	86.9000	$\bar{T}$, SCUBA (MIN/DIVE)
24	164.2664	47.9874	7.9979	36	263.0000	97.5000	165.5000	$\bar{T}$, REBREATHER
25	78.2790	27.0996	3.9115	48	149.0000	30.7083	118.2917	$\bar{T}$, DAYLIGHT
26	81.0559	118.5456	17.1106	48	873.0000	23.5714	849.4285	$\bar{T}$, NIGHT
27	0.3744	0.2301	0.0384	36	0.8986	0.1106	0.7880	RATIO: T_R / T
28	0.2045	0.0927	0.0134	48	0.4452	0.0267	0.4185	RATIO: T_N / T
29	0.2030	0.1701	0.0280	37	0.8000	0.0455	0.7545	RATIO: N_R / N
30	0.2256	0.0983	0.0142	48	0.5652	0.0286	0.5366	RATIO: N_N / N

AI. DIVING STATISTICS - TOTAL TEKTITE 2 SCIENTIFIC PROGRAM

VAR NO	MEAN	S.D.	S.E. OF MEAN	SAMPLE	MAXIMUM	MINIMUM	RANGE	VARIABLE
1	17.5999	2.9768	0.4707	40	21.0000	12.0000	9.0000	MISSION DAYS
2	3286.6226	1110.8679	175.6436	40	5976.0000	1288.0000	4688.0000	T TOTAL DIVE TIME (MIN)
3	2274.6479	1141.6177	180.5056	40	5040.0000	289.0000	4751.0000	T_S TOTAL SCUBA (MIN)
4	1304.1917	755.9670	135.7757	31	2826.0000	363.0000	2463.0000	T_R TOTAL REBREATH (MIN)
5	2642.2725	898.0889	142.0003	40	4932.0000	895.0000	4037.0000	T_D TOTAL, DAYLIGHT (MIN)
6	683.6472	414.9412	65.6080	40	1746.0000	41.0000	1705.0000	T_N TOTAL, NIGHT (MIN)
7	44.4249	12.1420	1.9198	40	69.0000	21.0000	48.0000	NUMBER OF DIVES (TOTAL)
8	37.7499	13.9646	2.2080	40	62.0000	6.0000	56.0000	NUMBER, SCUBA
9	8.6129	6.1518	1.1049	31	26.0000	2.0000	24.0000	NUMBER, REBREATHER
10	34.1499	10.5625	1.6701	40	65.0000	16.0000	49.0000	NUMBER, DAYLIGHT
11	10.0250	5.8155	0.9195	40	26.0000	1.0000	25.0000	NUMBER, NIGHT
12	187.7368	59.8372	9.4611	40	349.1428	80.7368	268.4058	AVG. MIN PER DAY, TOTAL
13	129.7583	61.4392	9.7144	40	265.2629	16.0555	249.2074	AVG. MIN PER DAY, SCUBA
14	74.7247	50.5445	9.0781	31	201.8571	24.5000	177.3571	AVG MIN PER DAY, RBTHR
15	151.3056	50.6821	8.0135	40	283.3569	74.5833	208.7736	AVG. MIN PER DAY, DAYLIGHT
16	38.3960	20.2287	3.1984	40	87.3000	2.1579	85.1421	AVG MIN PER DAY, NIGHT
17	2.5557	0.7004	0.1107	40	4.6667	1.5000	3.1667	$\bar{N}$ AVG. NUMBER PER DAY, TOTAL
18	2.1805	0.8589	0.1358	40	4.6667	0.3335	4.3333	$\bar{N}$, SCUBA
19	0.4841	0.3610	0.0648	31	1.4444	0.1053	1.3392	$\bar{N}$, REBREATHER
20	1.9654	0.6324	0.1000	40	4.1667	1.1429	3.0238	$\bar{N}$, DAYLIGHT
21	0.5778	0.3381	0.0535	40	1.8571	0.0526	1.8045	$\bar{N}$, NIGHT
22	75.7270	22.7286	3.5937	40	125.3333	37.4222	87.9111	$\bar{T}$ AVG. DIVE DURATION, TOTAL
23	59.3425	18.3447	2.9006	40	94.0000	14.8333	79.1667	$\bar{T}$, SCUBA (MIN/DIVE)
24	168.4013	48.6943	8.7458	31	263.0000	97.5000	165.5000	$\bar{T}$, REBREATHER
25	80.5826	27.7861	4.3934	40	149.0000	36.2353	112.7647	$\bar{T}$, DAYLIGHT
26	85.8552	129.4654	20.4703	40	873.0000	23.5714	849.4285	$\bar{T}$, NIGHT
27	0.3663	0.2427	0.0436	31	0.8986	0.1106	0.7880	RATIO: T_R/T
28	0.2024	0.0951	0.0150	40	0.4452	0.0267	0.4185	RATIO: T_N/T
29	0.2148	0.1810	0.0325	31	0.8000	0.0455	0.7545	RATIO: N_R/N
30	0.2238	0.1030	0.0163	40	0.5652	0.0286	0.5366	RATIO: N_N/N

A2 DIVING STATISTICS - SCIENTISTS

VAR NO	MEAN	S.D.	S.E. OF MEAN	SAMPLE	MAXIMUM	MINIMUM	RANGE	VARIABLE
1	22.0000	8.1941	2.8970	8	30.0000	12.0000	18.0000	MISSION DAYS
2	1659.6245	902.3164	319.0171	8	3223.0000	761.0000	2462.0000	T TOTAL DIVE TIME (MIN)
3	1301.8745	651.8914	230.4785	8	2612.0000	452.0000	2160.0000	T_S TOTAL, SCUBA (MIN)
4	572.3999	348.4065	155.8121	5	1094.0000	202.0000	892.0000	T_R TOTAL, REBREATH (MIN)
5	1290.1245	678.4844	239.8805	8	2352.0000	609.0000	1743.0000	T_D TOTAL, DAYLIGHT (MIN)
6	369.4995	288.3425	101.9445	8	1010.0000	115.0000	895.0000	T_N TOTAL, NIGHT (MIN)
7	25.8750	11.5936	4.0989	8	46.0000	13.0000	33.0000	NUMBER OF DIVES, TOTAL
8	23.0000	10.1980	3.6056	8	41.0000	10.0000	31.0000	NUMBER, SCUBA
9	3.8333	2.7142	1.1081	6	8.0000	1.0000	7.0000	NUMBER, REBREATHER
10	19.5000	8.0356	2.8410	8	32.0000	10.0000	22.0000	NUMBER, DAYLIGHT
11	6.3750	4.1726	1.4752	8	14.0000	2.0000	12.0000	NUMBER, NIGHT
12	79.1120	36.8454	13.0268	8	133.7857	37.3333	96.4524	AVG. MIN PER DAY, TOTAL
13	63.0663	29.6809	10.4938	8	109.0000	25.1111	83.8889	AVG MIN PER DAY, SCUBA
14	25.6732	15.9274	7.1230	5	46.1429	6.9655	39.1773	AVG MIN PER DAY, REBR.
15	61.6414	27.8921	9.8614	8	102.0714	24.5667	77.5048	AVG MIN PER DAY, DAYLIGHT
16	17.4706	10.9398	3.8678	8	33.6667	3.9655	29.7011	AVG MIN PER DAY, NIGHT
17	1.2147	0.4387	0.1551	8	2.0714	0.7222	1.3492	$\bar{N}$ AVG NUMBER PER DAY, TOTAL
18	1.0807	0.3710	0.1312	8	1.7143	0.5556	1.1587	$\bar{N}$, SCUBA
19	0.1787	0.1216	0.0496	6	0.3571	0.0345	0.3227	$\bar{N}$, REBREATHER
20	0.9071	0.2510	0.0387	8	1.3571	0.5556	0.8016	$\bar{N}$, DAYLIGHT
21	0.3075	0.1991	0.0704	8	0.7143	0.0690	0.6453	$\bar{N}$, NIGHT
22	64.2170	17.9201	6.3357	8	95.3750	35.0000	60.3750	$\bar{T}$ AVG. DIVE DURATION, TOTAL
23	57.8089	19.8418	7.0151	8	101.7333	35.0000	66.7333	$\bar{T}$, SCUBA (MIN / DIVE)
24	138.6300	37.5754	16.8042	5	202.0000	103.0000	99.0000	$\bar{T}$, REBREATHER
25	66.7616	21.1529	7.4787	8	100.5833	30.7083	69.8750	$\bar{T}$, DAYLIGHT
26	57.0596	13.5002	4.7730	8	79.7500	40.3333	39.4167	$\bar{T}$, NIGHT
27	0.3004	0.1167	0.0522	5	0.4060	0.1617	0.2443	RATIO: T_R / T
28	0.2150	0.0847	0.0299	8	0.3420	0.0921	0.2499	RATIO: T_N / T
29	0.1418	0.0808	0.0330	6	0.2308	0.0476	0.1832	RATIO: N_R / N
30	0.2344	0.0749	0.0265	8	0.3448	0.0952	0.2496	RATIO: N_N / N

A3. DIVING STATISTICS - ENGINEERS

VAR NO	MEAN	S.D.	S.E. OF MEAN	SAMPLE	MAXIMUM	MINIMUM	RANGE	VARIABLE
1	14.0000	0.0	0.0	4	14.0000	14.0000	0.0	MISSION DAYS
2	3494.5002	1091.0127	545.5063	4	4888.0000	2619.0000	2269.0000	T TOTAL DIVE TIME (MIN)
3	2049.7500	963.7029	481.8513	4	3050.0000	734.0000	2316.0000	T_S TOTAL SCUBA (MIN)
4	1444.7500	1073.1453	536.5725	4	2729.0000	363.0000	2366.0000	T_R TOTAL REBREATH (MIN)
5	2909.2500	875.7183	437.8591	4	3967.0000	2189.0000	1778.0000	T_D TOTAL DAYLIGHT (MIN)
6	585.2496	230.0468	115.0234	4	921.0000	429.0000	492.0000	T_N TOTAL NIGHT (MIN)
7	30.5000	8.4261	4.2131	4	39.0000	21.0000	18.0000	NUMBER OF DIVES - TOTAL
8	23.5000	9.1833	4.5917	4	33.0000	11.0000	22.0000	NUMBER - SCUBA
9	7.0000	5.3541	2.6771	4	13.0000	2.0000	11.0000	NUMBER - REBREATHER
10	24.0000	6.6833	3.3417	4	30.0000	16.0000	14.0000	NUMBER - DAYLIGHT
11	6.5000	2.3805	1.1902	4	10.0000	5.0000	5.0000	NUMBER - NIGHT
12	249.6070	77.9294	38.9647	4	349.1428	187.0714	162.0714	AVG MIN PER DAY - TOTAL
13	146.4107	68.8359	34.4180	4	217.8571	52.4286	165.4286	AVG MIN PER DAY - SCUBA
14	103.1964	76.6532	38.3266	4	194.9286	25.9286	169.0000	AVG MIN PER DAY - RBTHR
15	207.8035	62.5512	31.2756	4	283.3569	156.3571	126.9998	AVG MIN PER DAY - DAYLIGHT
16	41.8036	16.4319	8.2160	4	65.7857	30.6429	35.1429	AVG. MIN PER DAY - NIGHT $\bar{\bar{T}}$
17	2.1786	0.6019	0.3009	4	2.7857	1.5000	1.2857	$\bar{N}$, AVG NUMBER PER DAY - TOTAL
18	1.6786	0.6560	0.3280	4	2.3571	0.7857	1.5714	$\bar{N}$, SCUBA
19	0.5000	0.3824	0.1912	4	0.9286	0.1429	0.7857	$\bar{N}$, REBREATHER
20	1.7143	0.4774	0.2387	4	2.1429	1.1429	1.0000	$\bar{N}$, DAYLIGHT
21	0.4643	0.1700	0.0850	4	0.7143	0.3571	0.3571	$\bar{N}$, NIGHT
22	114.5091	12.7294	6.3647	4	125.3333	100.7308	24.6026	$\bar{T}$ AVG DIVE DURATION, TOTAL
23	84.0475	12.5197	6.2599	4	94.0000	66.7273	27.2727	$\bar{T}$, SCUBA (MIN / DIVE)
24	211.0558	36.6280	18.3140	4	263.0000	181.5000	81.5000	$\bar{T}$, REBREATHER
25	121.8978	17.3521	8.6761	4	136.8125	104.2857	32.5268	$\bar{T}$, DAYLIGHT
26	89.4583	2.8644	1.4322	4	92.1000	85.8000	6.3000	$\bar{T}$, NIGHT
27	0.4059	0.2794	0.1397	4	0.7211	0.1386	0.5825	RATIO : T_R / T
28	0.1658	0.0187	0.0094	4	0.1884	0.1427	0.0457	RATIO : T_N / T
29	0.2424	0.1963	0.0982	4	0.4762	0.0769	0.3993	RATIO : N_R / N
30	0.2134	0.0412	0.0206	4	0.2564	0.1667	0.0897	RATIO : N_N / N

A4 DIVING STATISTICS – FEMALE SCIENTISTS

VAR NO	MEAN	S.D.	S.E. OF MEAN	SAMPLE	MAXIMUM	MINIMUM	RANGE		VARIABLE
1	17.9999	2.8685	0.4781	36	21.0000	12.0000	9.0000		MISSION DAYS
2	3263.5261	1125.8547	187.6425	36	5976.0000	1288.0000	4688.0000	T	TOTAL DIVE TIME (MIN)
3	2299.6372	1168.8501	194.8083	36	5040.0000	289.0000	4751.0000	T_S	TOTAL SCUBA (MIN)
4	1283.3689	723.2124	139.1823	27	2826.0000	472.0000	2354.0000	T_R	TOTAL REBREATH (MIN)
5	2612.6091	907.7219	151.2870	36	4932.0000	895.0000	4037.0000	T_D	TOTAL DAYLIGHT (MIN)
6	694.5813	431.3792	71.8965	36	1746.0000	41.0000	1705.0000	T_N	TOTAL NIGHT (MIN)
7	45.9721	11.5572	1.9262	36	69.0000	24.0000	45.0000		NUMBER OF DIVES - TOTAL
8	39.3332	13.5751	2.2625	36	62.0000	6.0000	56.0000		NUMBER - SCUBA
9	8.8516	6.3167	1.2156	27	26.0000	2.0000	24.0000		NUMBER - REBREATHER
10	35.2776	10.3637	1.7273	36	65.0000	19.0000	46.0000		NUMBER - DAYLIGHT
11	11.4167	5.9684	0.9947	36	26.0000	1.0000	25.0000		NUMBER - NIGHT
12	180.8623	54.6174	9.1029	36	314.5261	80.7368	233.7893		AVG MIN PER DAY TOTAL
13	127.9081	61.3583	10.2264	36	265.2629	16.0555	249.2074		AVG MIN PER DAY, SCUBA
14	70.5067	46.1154	8.8749	27	201.8571	24.5000	177.3571		AVG MIN PER DAY, RBTHR
15	145.0281	46.0604	7.6767	36	259.5789	74.5833	184.9955		AVG MIN PER DAY, DAYLIGHT
16	38.0174	20.7689	3.4615	36	87.3000	2.1579	85.1421		AVG. MIN PER DAY, NIGHT
17	2.5976	0.7053	0.1176	36	4.6667	1.6111	3.0556	$\bar{N}$	AVG NUMBER PER DAY, TOTAL
18	2.2363	0.8678	0.1446	36	4.6667	0.3333	4.3333		$\bar{N}$, SCUBA
19	0.4818	0.3653	0.0703	27	1.4444	0.1053	1.3392		$\bar{N}$, REBREATHER
20	1.9933	0.6466	0.1078	36	4.1667	1.2105	2.9561		$\bar{N}$, DAYLIGHT
21	0.5904	0.3511	0.0585	36	1.8571	0.0526	1.8045		$\bar{N}$, NIGHT
22	71.4179	19.2549	3.2091	36	105.9500	37.4222	68.5278	$\bar{T}$	AVG DIVE DURATION, TOTAL
23	56.5976	16.8539	2.8090	36	90.0000	14.8333	75.1667		$\bar{T}$, SCUBA (MIN/DIVE)
24	162.0821	47.5369	9.1485	27	240.0000	97.5000	142.5000		$\bar{T}$, REBREATHER
25	75.9920	24.8544	4.1424	36	149.0000	36.2353	112.7647		$\bar{T}$, DAYLIGHT
26	85.4549	136.6547	22.7758	36	873.0000	23.5714	849.4285		$\bar{T}$, NIGHT
27	0.3834	0.2427	0.0467	27	0.8986	0.1106	0.7880		RATIO: T_R/T
28	0.2065	0.0994	0.0166	36	0.4452	0.0267	0.4185		RATIO: T_N/T
29	0.2108	0.1822	0.0351	27	0.8000	0.0455	0.7545		RATIO: N_R/N
30	0.2250	0.1080	0.0180	36	0.5652	0.0286	0.5366		RATIO: N_N/N

A5 DIVING STATISTICS – MALE SCIENTISTS

VAR NO	MEAN	S.D.	S.E. OF MEAN	SAMPLE	MAXIMUM	MINIMUM	RANGE	VARIABLE
1	23.1428	8.1328	3.0739	7	30.0000	12.0000	18.0000	MISSION DAYS
2	1678.7141	972.8667	367.7090	7	3223.0000	761.0000	2462.0000	T TOTAL DIVE TIME (MIN)
3	1269.8569	697.2959	263.5530	7	2612.0000	452.0000	2160.0000	T_S TOTAL SCUBA (MIN)
4	572.3999	348.4067	155.8122	5	1094.0000	202.0000	892.0000	T_R TOTAL REBREATH (MIN)
5	1301.9995	731.9485	276.6504	7	2352.0000	609.0000	1743.0000	T_D TOTAL DAYLIGHT (MIN)
6	376.7139	310.6646	117.4202	7	1010.0000	115.0000	895.0000	T_N TOTAL NIGHT (MIN)
7	27.2857	11.7575	4.4439	7	46.0000	13.0000	33.0000	NUMBER OF DIVES - TOTAL
8	24.1428	10.4472	3.9487	7	41.0000	10.0000	31.0000	NUMBER - SCUBA
9	4.4000	2.6077	1.1662	5	8.0000	1.0000	7.0000	NUMBER - REBREATHER
10	20.5714	8.0386	3.0383	7	32.0000	10.0000	22.0000	NUMBER - DAYLIGHT
11	6.7143	4.3861	1.6578	7	14.0000	2.0000	12.0000	NUMBER - NIGHT
12	74.8423	37.5992	14.2111	7	133.7857	37.3333	96.4524	AVG. MIN. PER DAY - TOTAL
13	56.5043	25.0179	9.4559	7	87.6429	25.1111	62.5318	AVG MIN PER DAY - SCUBA
14	25.6732	15.9274	7.1230	5	46.1429	6.9655	39.1773	AVG MIN PER DAY - RBTHR
15	58.1310	28.1535	10.6410	7	102.0714	24.5667	77.5048	AVG MIN PER DAY - DAYLIGH
16	16.7113	11.5864	4.3792	7	33.6667	3.9655	29.7011	AVG MIN PER DAY - NIGHT
17	1.2250	0.4728	0.1787	7	2.0714	0.7222	1.3492	$\bar{N}$ AVG NUMBER PER DAY - TOTAL
18	1.0820	0.4007	0.1514	7	1.7143	0.5556	1.1587	$\bar{N}$, SCUBA
19	0.2002	0.1225	0.0548	5	0.3571	0.0345	0.3227	$\bar{N}$, REBREATHER
20	0.9143	0.2702	0.1021	7	1.3571	0.5556	0.8016	$\bar{N}$, DAYLIGHT
21	0.3107	0.2148	0.0812	7	0.7143	0.0690	0.6453	$\bar{N}$, NIGHT
22	59.7659	13.7744	5.2062	7	78.2286	35.0000	43.2286	$\bar{T}$ AVG DIVE DURATION, TOTAL
23	51.5340	9.5821	3.6217	7	63.7073	35.0000	28.7073	T, SCUBA (MIN/DIVE)
24	138.6300	37.5754	16.8042	5	202.0000	103.0000	99.0000	$\bar{T}$, REBREATHER
25	61.9299	17.4394	6.5915	7	84.0000	30.7083	53.2917	$\bar{T}$, DAYLIGHT
26	53.8182	10.7035	4.0455	7	72.1429	40.3333	31.8095	T, NIGHT
27	0.3004	0.1167	0.0522	5	0.4060	0.1617	0.2443	RATIO : T_R/T
28	0.2158	0.0914	0.0345	7	0.3420	0.0921	0.2499	RATIO : T_N/T
29	0.1576	0.0792	0.0354	5	0.2308	0.0476	0.1832	RATIO : N_R/N
30	0.2322	0.0807	0.0305	7	0.3448	0.0952	0.2496	RATIO : N_N/N

A6 DIVING STATISTICS - MALE ENGINEERS

VAR NO	MEAN	S.D.	S.E. OF MEAN	SAMPLE	MAXIMUM	MINIMUM	RANGE	VARIABLE
1	18.2580	2.4896	0.4471	31	21.0000	14.0000	7.0000	MISSION DAYS
2	3612.3530	990.9558	177.9809	31	5976.0000	1531.0000	4445.0000	T TOTAL DIVE TIME (MIN)
3	2306.5786	1246.8455	223.9400	31	5040.0000	289.0000	4751.0000	T_S TOTAL SCUBA (MIN)
4	1304.1924	755.9661	135.7755	31	2826.0000	363.0000	2463.0000	T_R TOTAL, REBREATH. (MIN)
5	2893.9019	811.4282	145.7368	31	4932.0000	1212.0000	3720.0000	T_D TOTAL, DAYLIGHT (MIN)
6	769.1594	415.6631	74.6553	31	1746.0000	184.0000	1562.0000	T_N TOTAL, NIGHT (MIN)
7	44.8064	13.1995	2.3707	31	69.0000	21.0000	48.0000	NUMBER OF DIVES, TOTAL
8	36.1935	15.0209	2.6978	31	62.0000	6.0000	56.0000	NUMBER, SCUBA
9	8.6129	6.1518	1.1049	31	26.0000	2.0000	24.0000	NUMBER, REBREATH
10	33.8386	11.3728	2.0426	31	65.0000	16.0000	49.0000	NUMBER, DAYLIGHT
11	10.6452	6.0473	1.0861	31	26.0000	2.0000	24.0000	NUMBER, NIGHT
12	199.7689	56.6041	10.1664	31	349.1428	109.3571	239.7857	AVG. MIN PER DAY, TOTAL
13	124.9581	63.3694	11.3815	31	265.2629	16.0555	249.2074	AVG MIN PER DAY, SCUBA
14	74.7247	50.5443	9.0780	31	201.8571	24.5000	177.3571	AVG. MIN PER DAY, RBTHR
15	160.4085	47.7442	8.5751	31	283.3569	86.5714	196.7855	AVG MIN PER DAY, DAYLIGHT
16	41.8958	20.4605	3.6748	31	87.3000	9.2000	78.1000	AVG MIN PER DAY, NIGHT
17	2.4354	0.5685	0.1021	31	3.4000	1.5000	1.9000	$\bar{N}$ AVG NUMBER PER DAY, TOTAL
18	1.9512	0.6852	0.1231	31	3.1000	0.3333	2.7667	$\bar{N}$, SCUBA
19	0.4841	0.3610	0.0648	31	1.4444	0.1053	1.3392	$\bar{N}$, REBREATHER
20	1.8323	0.4834	0.0868	31	3.2500	1.1429	2.1071	$\bar{N}$, DAYLIGHT
21	0.5870	0.3501	0.0629	31	1.8571	0.1000	1.7571	$\bar{N}$, NIGHT
22	83.3403	19.4307	3.4899	31	125.3333	56.3571	68.9762	$\bar{T}$ AVG DIVE DURATION, TOTAL
23	62.1990	19.2924	3.4650	31	94.0000	14.8333	79.1667	$\bar{T}$, SCUBA (MIN/DIVE)
24	168.4013	48.6943	8.7458	31	263.0000	97.5000	165.5000	$\bar{T}$, REBREATHER
25	89.5521	24.5346	4.4065	31	149.0000	59.4921	89.5079	$\bar{T}$, DAYLIGHT
26	97.0359	145.5725	26.1456	31	873.0000	23.5714	849.4285	$\bar{T}$, NIGHT
27	0.3840	0.2427	0.0436	31	0.8986	0.1106	0.7880	RATIO: T_R/T
28	0.2089	0.0912	0.0164	31	0.4452	0.0453	0.3999	RATIO: T_N/T
29	0.2148	0.1810	0.0325	31	0.8000	0.0455	0.7545	RATIO: N_R/N
30	0.2361	0.1006	0.0181	31	0.5652	0.0308	0.5344	RATIO: N_N/N

A7 DIVING STATISTICS - REBREATHER USERS

VAR NO	MEAN	S.D.	S.E. OF MEAN	SAMPLE	MAXIMUM	MINIMUM	RANGE	VARIABLE
1	15.3333	3.5355	1.1785	9	19.0000	12.0000	7.0000	MISSION DAYS
2	2164.6663	711.4497	237.1499	9	3192.0000	1288.0000	1904.0000	T TOTAL DIVE TIME (MIN)
3	2164.6663	711.4497	237.1499	9	3192.0000	1288.0000	1904.0000	T_S TOTAL, SCUBA (MIN)
NO DATA FOR THIS VARIABLE								
5	1775.5552	610.3359	203.4453	9	2553.0000	895.0000	1658.0000	T_D TOTAL, DAYLIGHT (MIN)
6	389.1106	255.9708	85.3236	9	837.0000	41.0000	796.0000	T_N TOTAL, NIGHT (MIN)
7	43.1111	7.9285	2.6428	9	56.0000	31.0000	25.0000	NUMBER OF DIVES, TOTAL
8	43.1111	7.9285	2.6428	9	56.0000	31.0000	25.0000	NUMBER, SCUBA
NO DATA FOR THIS VARIABLE								
10	35.2222	7.5627	2.5209	9	50.0000	22.0000	28.0000	NUMBER, DAYLIGHT
11	7.8889	4.5947	1.5316	9	14.0000	1.0000	13.0000	NUMBER, NIGHT
12	146.2929	54.2817	18.0939	9	240.3333	80.7368	159.5965	AVG. MIN PER DAY, TOTAL
13	146.2929	54.2817	18.0939	9	240.3333	80.7368	159.5965	AVG. MIN PER DAY, SCUBA
NO DATA FOR THIS VARIABLE								
15	119.9513	50.4697	16.8232	9	212.7500	74.5833	138.1667	AVG. MIN PER DAY, DAYLIGHT
16	26.3415	14.6305	4.8768	9	44.0526	2.1579	41.8947	AVG. MIN PER DAY, NIGHT
17	2.9702	0.9644	0.3215	9	4.6667	1.8421	2.8246	$\bar{N}$ AVG NUMBER PER DAY, TOTAL
18	2.9702	0.9644	0.3215	9	4.6667	1.8421	2.8246	$\bar{N}$, SCUBA
NO DATA FOR THIS VARIABLE								
20	2.4242	0.8764	0.2921	9	4.1667	1.6842	2.4825	$\bar{N}$, DAYLIGHT
21	0.5460	0.3102	0.1034	9	0.9167	0.0526	0.8640	$\bar{N}$, NIGHT
22	49.5038	10.2143	3.4048	9	65.1429	37.4222	27.7206	$\bar{T}$ AVG DIVE DURATION, TOTAL
23	49.5038	10.2143	3.4048	9	65.1429	37.4222	27.7206	$\bar{T}$, SCUBA (MIN/DIVE)
NO DATA FOR THIS VARIABLE								
25	49.6876	10.9980	3.6660	9	66.6842	36.2353	30.4489	$\bar{T}$, DAYLIGHT
26	47.3438	9.5304	3.1768	9	59.8182	35.0000	24.8182	$\bar{T}$, NIGHT
NO DATA FOR THIS VARIABLE								
28	0.1801	0.1103	0.0368	9	0.3051	0.0267	0.2784	RATIO: T_N/T
NO DATA FOR THIS VARIABLE								
30	0.1813	0.1059	0.0353	9	0.3043	0.0286	0.2758	RATIO: N_N/N

A8 DIVING STATISTICS - NON REBREATHER USERS

VAR NO	MEAN	S.D.	S.E. OF MEAN	SAMPLE	MAXIMUM	MINIMUM	RANGE	VARIABLE
1	16.5000	3.6742	1.5000	6	21.0000	12.0000	9.0000	MISSION DAYS
2	3396.6667	1182.2761	482.6621	6	4888.0000	1715.0000	3173.0000	T TOTAL DIVE TIME (MIN)
3	2328.1665	976.8342	398.7908	6	3478.0000	792.0000	2686.0000	T_S TOTAL SCUBA (MIN)
4	1602.7500	909.0139	454.5068	4	2729.0000	585.0000	2144.0000	T_R TOTAL REBREATH (MIN)
5	2866.8335	1035.4636	422.7261	6	3967.0000	1257.0000	2710.0000	T_D TOTAL DAYLIGHT (MIN)
6	527.8330	332.2463	135.6390	6	962.0000	184.0000	778.0000	T_N TOTAL NIGHT (MIN)
7	49.6666	14.6105	5.9647	6	68.0000	29.0000	39.0000	NUMBER OF DIVES - TOTAL
8	42.0000	18.4065	7.5144	6	62.0000	14.0000	48.0000	NUMBER, SCUBA
9	11.5000	3.8730	1.9365	4	15.0000	6.0000	9.0000	NUMBER, REBREATHER
10	41.3333	15.4229	6.2964	6	65.0000	24.0000	41.0000	NUMBER, DAYLIGHT
11	8.3333	4.3205	1.7638	6	14.0000	3.0000	11.0000	NUMBER, NIGHT
12	210.2074	80.1988	32.7410	6	349.1428	122.5000	226.6428	AVG. MIN. PER DAY - TOTAL
13	145.8325	64.3990	26.2908	6	240.3333	44.0000	196.3333	AVG MIN PER DAY - SCUBA
14	96.5625	72.0695	36.0348	4	194.9286	29.2500	165.6786	AVG MIN PER DAY - RBTHR.
15	177.1458	68.2942	27.8810	6	283.3569	89.7857	193.5712	AVG. MIN PER DAY - DAY[illegible]HT
16	33.0618	20.4059	8.3307	6	65.7857	9.2000	56.5857	AVG. MIN PER DAY, NIGHT
17	3.0971	0.9911	0.4046	6	4.6667	1.6111	3.0556	$\bar{N}$ AVG. NUMBER PER DAY, TOTAL
18	2.6582	1.3283	0.5423	6	4.6667	0.7778	3.8889	$\bar{N}$, SCUBA
19	0.6583	0.2826	0.1413	4	0.9286	0.3000	0.6286	$\bar{N}$, REBREATHER
20	2.5694	0.9945	0.4060	6	4.1667	1.3333	2.8333	$\bar{N}$, DAYLIGHT
21	0.5276	0.2715	0.1108	6	0.8571	0.1500	0.7071	$\bar{N}$, NIGHT
22	72.3758	31.3782	12.8101	6	125.3333	38.1111	87.2222	$\bar{T}$ AVG. DIVE DURATION, TOTAL
23	57.5563	14.6513	5.9814	6	83.0385	38.1111	44.9274	$\bar{T}$, SCUBA (MIN/DIVE)
24	133.7141	51.8873	25.9437	4	209.9231	97.5000	112.4231	$\bar{T}$, REBREATHER
25	75.1933	36.0426	14.7143	6	136.7931	38.0909	98.7022	$\bar{T}$, DAYLIGHT
26	62.9468	17.6687	7.2132	6	92.1000	38.1667	53.9333	$\bar{T}$, NIGHT
27	0.4252	0.2500	0.1250	4	0.6990	0.1440	0.5550	RATIO: T_R/T
28	0.1605	0.0825	0.0337	6	0.2671	0.0453	0.2218	RATIO: T_N/T
29	0.2839	0.1851	0.0925	4	0.5172	0.0882	0.4290	RATIO: N_R/N
30	0.1794	0.0890	0.0363	6	0.2667	0.0441	0.2225	RATIO: N_N/N

A9 [1]DIVING STATISTICS ~ TEAM LEADERS

VAR NO	MEAN	S.D.	S.E. OF MEAN	SAMPLE	MAXIMUM	MINIMUM	RANGE	VARIABLE
1	16.4999	3.4513	0.8135	18	21.0000	12.0000	9.0000	MISSION DAYS
2	3212.9988	1127.9866	265.8689	18	5473.0000	1288.0000	4185.0000	T TOTAL DIVE TIME (MIN)
3	1930.9434	1182.1975	278.6465	18	4005.0000	289.0000	3716.0000	T_S TOTAL, SCUBA (MIN)
4	1535.3325	840.3337	216.9733	15	2826.0000	363.0000	2463.0000	T_R TOTAL, REBREATHER (MIN)
5	2549.3320	851.2563	200.6431	18	4117.0000	895.0000	3222.0000	T_D TOTAL, DAYLIGHT (MIN)
6	750.9990	481.0620	113.3874	18	1746.0000	262.0000	1484.0000	T_N TOTAL, NIGHT (MIN)
7	43.2222	14.4367	3.4028	18	69.0000	21.0000	48.0000	NUMBER OF DIVES, TOTAL
8	34.4444	15.7227	3.7059	18	60.0000	6.0000	54.0000	NUMBER, SCUBA
9	10.5333	7.4725	1.9294	15	26.0000	2.0000	24.0000	NUMBER, REBREATHER
10	31.9444	11.8593	2.7953	18	63.0000	16.0000	47.0000	NUMBER, DAYLIGHT
11	11.2778	7.2906	1.7184	18	26.0000	2.0000	24.0000	NUMBER, NIGHT
12	193.1226	51.9706	12.2496	18	274.2141	107.3333	166.8808	AVG. MIN PER DAY, TOTAL
13	117.3673	64.5396	15.2121	18	217.8571	16.0555	201.8016	AVG MIN PER DAY, SCUBA
14	90.7354	54.4128	14.0493	15	201.8571	25.5500	176.3071	AVG MIN PER DAY, RBTHR
15	154.0760	43.8085	10.3258	18	235.0714	74.5833	160.4881	AVG MIN PER DAY, DAYLIGHT
16	43.4132	20.9408	4.9358	18	87.3000	21.3333	65.9667	AVG MIN PER DAY, NIGHT
17	2.6240	0.7127	0.1680	18	3.8333	1.5000	2.3333	$\bar{N}$ AVG NUMBER PER DAY, TOTAL
18	2.1169	0.9302	0.2193	18	3.8333	0.3333	3.5000	$\bar{N}$, SCUBA
19	0.6085	0.4275	0.1104	15	1.4444	0.1429	1.3016	$\bar{N}$, REBREATHER
20	1.9439	0.6323	0.1490	18	3.4167	1.1429	2.2738	$\bar{N}$, DAYLIGHT
21	0.6801	0.4198	0.0990	18	1.8571	0.1000	1.7571	$\bar{N}$, NIGHT
22	77.3200	23.7551	5.5991	18	125.3333	37.4222	87.9111	$\bar{T}$ AVG. DIVE DURATION, TOTAL
23	55.4251	20.3390	4.7939	18	94.0000	14.8333	79.1667	$\bar{T}$, SCUBA (MIN/DIVE)
24	165.9965	51.9277	13.4077	15	263.0000	102.2000	160.8000	$\bar{T}$, REBREATHER
25	84.9244	30.8481	7.2710	18	149.0000	36.2353	112.7647	$\bar{T}$, DAYLIGHT
26	109.1659	191.7862	45.2044	18	873.0000	23.5714	849.4285	$\bar{T}$, NIGHT
27	0.4632	0.2732	0.0706	15	0.8986	0.1303	0.7683	RATIO : T_R/T
28	0.2254	0.0888	0.0209	18	0.4452	0.1015	0.3437	RATIO : T_N/T
29	0.2657	0.2166	0.0559	15	0.8000	0.0612	0.7388	RATIO : N_R/N
30	0.2550	0.1184	0.0279	18	0.5652	0.0308	0.5344	RATIO : N_N/N

A10 DIVING STATISTICS - NON LEADERS