WOMEN IN DIVING

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Finally, Dr. Leon J. Greenbaum, Jr., and the staff of the Undersea and Hyperbaric Medical Society brought together all the components that culminated in this volume, and their contribution is also acknowledged.

INTRODUCTORY REMARKS

GREENBAUM: I would like to thank you all for coming to participate in this workshop. And I welcome you to the Society offices and to the Society's building. This workshop, like many other workshops that preceded it, was conceived and arranged by Dr. Shilling. So I would like to, at this point, ask Chuck to say a word or two.

SHILLING: One of the questions that was mast frequently asked when I sat at the desk that you now have, Leon, was concern about women in diving, pregnancy, sharks, and the menstrual period. We received all kinds of such questions over and over. We had one workshop that I think all of you will remember, particularly Ed Lanphier, a workshop dealing with pregnancy and diving. But the questions still are coming in and we don't have really true answers to a great many of them. So we decided, by talking to a number of people, all of whom agreed that it would be a wise idea to have one more try to see if we can clarify same of the issues that face the female public when it comes to diving, and that's the reason that we got this started. I'm sure it's going to be good with the Chairman we've got and with all the rest of you here. Welcome aboard.

GREENBAUM: I must say, it's very interesting because the workshop that was held last week on fitness to dive didn't have one female participant as part of the panel. And it's a nice contrast.

FIFE: Thank you Dr. Greenbaum. We greatly appreciate your hospitality and the support of your staff in planning and carrying out this Workshop. We also wish to express our special appreciation to Mr. Norman Portenoy and to the Max and Victoria Dreyfus Foundation for the financial support that made this possible. It is also nice to have Dr. Shilling with us since he was the one who initiated this Workshop before he retired. I would like to outline what I think are the goals of the Workshop on Women in Diving. First, it is to assemble under one cover as much information as we can on the subject. As we all know, there have been numerous articles, speculations, and research reports on many aspects of this subject. They have appeared in the public press, sports journals, professional journals, and in innumerable speeches. Unfortunately, while a large body of facts have been accumulated, in retrospect some of the studies suffer from a lack of adequate controls. There also has developed a large amount of anecdotal and folklore reports, some of which is reasonable, but much of which is without factual foundation. We would like to winnow out the folklore and organize the facts.

A second goal is perhaps to answer a few more questions. The purpose, of course, is to provide physicians and women divers with a better basis on which to make decisions concerning diving. We hope to present some new information, to push back the frontiers a little more, and perhaps to put to rest some of the concerns that have crept into diving folklore regarding the supposed differences between women and men divers.

Finally, at the end I would like us to be able to spend some time discussing problem areas, to identify those that apparently need some

additional answers. This should result in some suggestions for further research, as well as identify what might be called "non-problems" which can be laid to rest. I suspect that we will find many of these.

I hope there will be some controversy because I know we have some differences of opinions within this group. Let us have everybody's opinions in free discussion.

PREGNANCY AND DIVING

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The subject of Pregnancy and Diving is especially important to the total picture of women in diving, so I searched diligently for new information. I found relatively little that is both relevant and basically new since the workshop on Effects of Diving on Pregnancy held here in 1978 (1). I found practically nothing new since 1983, when I last surveyed this area.

The paper that I wrote in 1983 and presented in Japan had a deliberately provocative title, Should Women Dive? (2). In it, I attempted to pull together every significant bit of real information that I could find; and I gave Pregnancy and Diving a good deal of attention. That paper represented a good effort, and little has happened since; so I will use it as the starting-point for what I have to say here.

Table 1 is from that publication. In it, I put down almost every conceivable objection or complication that anyone had suggested up to that time. As you will note, a few of the entries seem likely to be important. Many others are no doubt inconsequential. In very few cases do we have reliable information one way or the other.

TABLE 1

Potential Problems of the Pregnant Diver

A. Maternal factors

Morning sickness + motion sickness
Reduced respiratory function
Circulatory competition with placenta
Altered sympathetic response
Reduced fitness and endurance; unusual fatigue
Size: fit of suit, harness, etc.; clumsiness => injury
Effects of lifting
Increased fat and fluid => increased susceptibility to DCS
Mucous membrane swelling => difficulty clearing ears

B. Fetal factors

1. General
   - Hypoxia from various mishaps
   - Hyperoxia => blindness? closure of ductus?
     hemoglobin breakdown? consumptive coagulopathy?
   - Exercise hyperglycemia; post-exercise hypoglycemia
   - Exercise hyperthermia
   - Physical injury
   - Leaking membranes => infection
   - Maternal envenomation => direct or indirect damage
   - Decompression => bubbles => altered placental flow

2. Early
   - Malformations related to maternal DCS
   - Teratogenic effects of pressure? oxygen? nitrogen?
     dive-related medications? bubble formation? other?
   - Recompression Rx => exceptional exposure to O_2 and N_2
   - Decompression => bubbles => birth defects

3. Late
   - Prematurity (Ama diving)
   - Decompression => stillbirth

From Lanphier (1983).

FETAL VS MATERNAL BUBBLES

One of the main problems I encountered in writing my 1983 paper was the amount of frankly contradictory information. I tried to deal with this by posing certain basic questions, lining up the relevant papers, and then trying to reach some conclusion about the "balance" of evidence. Table 2 is a good example of this process.

The comment [artifact?] under Fife '78 requires some explanation. In the study in question, Fife and his associates placed a Doppler probe around an umbilical vessel in seven near-term fetal sheep. Compression and decompression produced marked evidence of fetal bubbling while no evidence of decompression sickness was noted in the mothers. Understandably Fife, Simmang, and Kitzman (3) concluded that bubbles were much more likely to form in the fetus than in the mother.

For a number of reasons, Dr. John H.G. Rankin, the leading fetal physiologist at the University of Wisconsin, did not believe Fife's findings. Consequently, we undertook a similar study using Rankin's method of placing catheters in maternal and fetal blood vessels and using radioactive microspheres to evaluate blood flow in different regions at different times.

Our initial findings emphatically confirmed those of Fife et al. Every fetus was in obvious difficulty beyond about 20 min after decompression from simulated air dives on "no decompression" schedules. All died, and all were found to have massive vascular bubbling.

TABLE 2

Are Post-Dive Bubbles More Likely to Form in the Fetus that in the Mother?

YES	NO	
Fife '78 sheep, late [artifact?]	Boycott '08 goat, early	Nemiroff '81 sheep, late
Fife, unpub. sheep, early (resorption)	McIver '68 dog, late	Powell '81 sheep, goat; late
	Chen '74 rat, late	Willson '83 sheep, late
	Stock '80 sheep, late	

From Lanphier (1983).

One ewe caused us to start "control" experiments sooner than we intended. She had twins, and we instrumented only one of them. The instrumented lamb followed the inevitable course; but the other one seemed perfectly all right. After this, we deliberately ran more twin pairs as well as pregnant ewes that were not manipulated at all. The results were as black vs white: instrumented lambs always died; those left alone all survived.

We concluded that our own findings in instrumented fetal lambs, and Fife's as well, stemmed from something about the experimental procedure. Our findings were reported in a paper by Stock, Lanphier, Anderson, Anderson, Phernetton and Rankin (4) and in Stock's dissertation (5). Exactly why our procedure caused bubbling remains uncertain. Why Fife's less invasive procedure did so is even more of a mystery.

Table 2 clearly suggests that bubbles are *less* likely to form in the fetus than in the mother. However, we dare not carry this conclusion very far. It does not tell us that a dive that does not produce decompression sickness in a pregnant woman will necessarily be safe for her fetus.

The most basic issue here is a well-known fact of fetal anatomy and physiology. In the adult, virtually the entire cardiac output goes through the lungs, which act as an effective bubble filter. In the fetus, most of the blood bypasses the lungs by going through the ductus arteriosus and the open foramen ovale. Thus, any bubble that forms for any reason in the fetus potentially becomes a life-threatening embolus it the brain or heart. In could cause damage wherever it might lodge. Such considerations led to an attempt at a maxim:

ANY bubbles in the FETUS
are more ominous than
MANY bubbles in the MOTHER

If the mother developed decompression sickness, bubbling in the fetus would presumably be more likely than under ordinary circumstances. Finally, treatment of the mother by recompression would further endanger the fetus with increased oxygen pressure. This is true even if an air treatment table is used; and air treatment offers the additional threat of greater uptake of nitrogen.

DECOMPRESSION SICKNESS AND STILLBIRTH

Another question that I tried to "balance" in indicated in Table 3.

TABLE 3

Is the Fetus Likely to be Injured or Killed if the Mother Develops Decompression Sickness late in Pregnancy?

YES	NO
Lehner '82 sheep	McIver '68 dog
Willson '83 sheep	Chen '74 rat

From Lanphier (1983).

In the observations of Lehner, Rynning, Bolton, and Lanphier (6), all lambs that were delivered soon after maternal DCS were stillborn. We never saw a normal birth that shortly followed maternal DCS. The findings of Willson, Blessed, and Blackburn (7) are also consistent with the impression that, as the fetus matures, gas supersaturation sufficient to produce DCS in the mother is increasingly likely to result in the death of the fetus. The positive evidence from sheep seems stronger than the negative findings in dogs and rats.

BIRTH DEFECTS

The possibility of birth defects is probably foremost in the minds of most women who are, or might be, pregnant and who wish to continue diving.

Again, I tried to deal with the evidence by posing a question and lining up the "yes" and "no" answers. Table 4 is the result.

In this case, the "yes" and "no" columns look about equally balanced; but the truth is probably not that simple.

Despite being open to criticism in some respects, Margie Bolton's survey (8) provided the best information brought forth at the 1978 workshop

TABLE 4

Does Diving Cause Birth Defects?

YES	NO
Bolton '80 human [survey]	Bangasser '78 human [survey]
Turner '82 human [one case]	Bolton & Alamo '81 rat
Gilman '82 hamster	Bolton-Klug '83 sheep

From Lanphier (1983).

and the best that we have now. I will examine her study in more detail shortly.

Focusing on this table for the moment, the one human case reported by Turner and Unsworth (9) and the hamster study of Gilman, Greene, Bradley, and Biersner (10) might not weigh heavily on the "yes" side if they were alone.

On the "no" side, Bangasser (11) represents an impressive survey, but it included fewer women who dived during pregnancy and also fewer deep divers than Bolton's data.

Bolton and Alamo (12) and Bolton-Klug, Lehner, Lanphier, and Rankin (13) are both respectable animal studies with exposures that produced maternal DCS; but the numbers of animals were relatively small. If the true incidence of defects resulting from diving is as small in animals as in Bolton's study of pregnant women, much larger groups of animals would be required to reach valid conclusions.

Most birth defects arise during the first trimester, perhaps even before the mother realizes that she is pregnant. The uncomfortable implications of this fact for divers have been spelled out by several authors.

There are two main criticisms of Margie Bolton's questionnaire survey (8). One concerns the possibility of bias, inherent in retrospective studies in which individuals are free to respond or not. Perhaps, for example, women who had trouble were more likely to respond than those who did not. To me, the opposite hypothesis seems at least equally tenable; but there is no way to know the truth.

The numbers in Margie's survey can be confusing. The next two tables help clarify what she did. Table 5 shows the actual number of questionnaires returned and how the responses were distributed.

TABLE 5
Bolton 1980: Response, etc.

Questionnaires returned (39 states, 10 countries; Pregnant in last 5 yrs Term after basic certification)	208
Dived during 1 or more pregnancies	136
Dived before, not during	72

In the hope of eliminating possible confusion, Margie narrowed the group before analyzing the complications. Table 6 shows what she did.

TABLE 6

Bolton, 1980: Delineated Subset

Last pregnancy only No extensive b'hold diving Lived in U.S.	
Total Subset	178
Dived during pregnancy	109
Dived before, not during	69

Table 7 shows the proportions of various complications in the subset.

The "did dive" group has the largest proportion of complications such as low birth weight, post-delivery respiratory difficulties, and other neonatal problems. But the figures on birth defects really stand out: 5.5% among the "dids" and zero among the "did nots."

Bolton herself commented on the fact that 5.5% was close to the expected incidence of birth defects in the general population. This provides an excuse for minimizing the significance of this finding. For example, Susan Bangasser is quoted in one popularized article (14) as saying that Margie's 5.5% "doesn't mean anything" for that reason.

TABLE 7

Bolton, 1980: Frequency of Fetal Complications in Women who DID or DID NOT dive during pregnancy (percent) [From Table 4, p 187]

Complication	DID dive	DID NOT dive
Spontaneous abortion	2.8	4.3
Therapeutic abortion	4.6	2.9
Stillbirth	0	0
Livebirth	92.6	89.9
Low birth weight	4.6	1.4
Birth defect	5.5	0
Post-delivery respiratory diff.	2.8	0
Other neonatal problems	3.7	1.4

What we need to know is the incidence in a truly comparable population. I have never found such a figure, but I suspect that it may be closer to the "no dive" group's zero than to 5.5%.

Table 8 gives details on the actual defects involved.

TABLE 8

Bolton, 1980: Birth Defects

Total infants with defects (all in *Did Dive* group)	6
Multiple hemivertebrae (mother dived 120 ft)	1
Absence of hand (mother dived 160 ft)	1
Ventricular septal defect	1
Possible coarct. of aorta	1
Hypertrophic pyloric stenosis	1
Hairy birthmark	1

Among these defects, only the hairy birthmark could possibly be called trivial. And at least until much better evidence comes along, I would have to accept the likelihood that diving had something to do with them.

The conclusions I reached in 1983 from all of the foregoing information were:

For the present, we must assume that

1. Diving can increase the incidence of birth defects.

2. Fetal resistance to bubble formation is offset by the consequences of bubble formation if that occurs for any reason.

3. Maternal DCS late in pregnancy entails a high risk of stillbirth. The risk may be increased by recompression.

With no new facts to go on, it would be difficult for me to change my mind.

SOURCES OF NEW INFORMATION

Where are significant new facts ever going to come from? The conclusions that can be taken from animal studies and applied to humans are admittedly limited. I have little enthusiasm for further animal studies unless newer and better ideas for them emerge.

An obvious thing to do would be to set up a prospective study in which pregnant divers are matched as well as possible and then randomly assigned to "dive" and "no dive" groups. However, it would be ethically irresponsible to consider any such thing if more than minimal exposures were involved. Whether such a study could be justified even, for example, to test Bangasser's 1978b recommendation (11) of 33 ft maximum depth is questionable in my mind.

The only practical answer may be for female divers to keep accurate records individually, to compile information on a national and international level, and by doing so to build up a "protective tradition" of applicable knowledge. Admittedly, this may take a long time.

CONCLUSIONS

It is the individual woman's responsibility to decide whether to dive during pregnancy or not, and she deserves to have "the facts," such as they are. At the same time, it seems incumbent upon professional people to have a considered opinion and to express it.

Time and space do not permit me to summarize the views of recent writers, but I have included in the references most of the relevant items that I have found. I particularly like what Dr. Judith Anderson (15) said when she wrote for Dr. Bove's column in *Skin Diver*. After saying that pregnant women should not dive and telling why, she said, "...a nine month diving hiatus seems a small price to pay for a healthy child with normal limbs and normal vision."

I might have said it the other way around: "A birth defect, with the possibility that it was caused by diving, would be a very high price for any

benefit that diving in pregnancy could possibly confer." If that betrays prejudice on my part, so be it.

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DISCUSSION FOLLOWING PRESENTATION BY DR. LANPHIER

FIFE: I would like to take the Chairman's privilege of making a couple of quick comments that may clarify one or two points. One of the things that Dr. Lanphier mentioned was that if a pregnant woman had to be treated, even on air, there may be some possible consequences to the fetus. I would like to enter one of Rankin's statements made at the U.M.S. 1978 workshop on the Effects of Pregnancy and Diving, concerning which I have not seen the experimental evidence. He apparently found that unless the inspired partial pressure of oxygen to the mother is above 500 millimeters of mercury, the closedown or the reduction in uterine artery blood flow tends to protect the fetus from having an increase in oxygen partial pressure. And therefore, one would not expect that to be a serious problem although there should be a buildup of CO_2 retention in the fetus.

One of the remarks I'd also like to make concerns the difference between the rats, dogs, and sheep and humans. I want to call attention to the fact that the rats and dogs have a counter-current blood flow between the placenta and the fetus. This is, therefore, a more efficient way of transferring gases both in and out, whereas sheep and humans have a labyrinthine type of circulation which is a less efficient type of gas exchange. And, in fact, that's why we went to the sheep after the work on the rat by Chin had been done in our laboratory and the work of McIver on the dog. When we realized that we were talking about two different circulatory patterns, we turned to sheep. And that's something that ought to be considered given the differences between those two.

One of the remarks I mentioned to you before we started concerned another paper which didn't appear on Dr. Lanphier's slides. And let me see. Dr. Magaletta, you had the paper which you gave me to be copied. Would you be able to make a remark about it?

LANPHIER: That was Powell and Smith. And as far as I can tell, it's the same data as Powell and Smith 1985. So actually, I have Powell and Smith 1985 in my references, but I had it in an abstract of theirs from 1981 that was included on the crucial table. So they finally got around to publishing it, which is nice. But it's not new information.

FIFE: Of course, however, their findings were that the fetus did develop bubbles even without surgery. (Undersea Biomedical Research 12:59, 1985. Ed).

LANPHIER: It developed bubbles -- much less so than the mother under given circumstances. That was the question in that particular table.

FIFE: But there is a question of the matter of the surgery. We've talked about this a number of times, what was there about our opening up the uterus and putting a transducer around the umbilical artery without any other violation of the fetal circulation that predisposed the fetus to develop circulating bubbles? What caused the problem? I have yet to find an answer as to why there was that difference. As you pointed out. It's a fascinating one.

MAGALETTA: Bill, I've thought about that and the explanation I've heard is that the ultrasound introduces cavitation and micronuclei.

FIFE: Well, I also thought about it years ago. So what I did was to instrument a sheep on the inferior vena cava with two transducers. And by activating the transducer which was downstream, that is, closer to the heart, and getting no indication of bubbles, and then activating the transducer which was upstream, which should have caused cavitation, it also produced no bubbles. Later on, after just waiting, the animal did produce bubbles. So the animal presumably was fairly super-saturated, for whatever that means.

MAGALETTA: If time is involved, it might not take more time than a short period to develop.

LANPHIER: I think you're right because according to Ed Lightfoot's calculations, just a few inches of distance along the vena cava probably wouldn't give enough time for bubbles to develop to a detectable size. I'd say it looks to me that more work needs to be done on this. And in one phase of our work, we just decided not to use a Doppler because we didn't know for sure whether this sort of thing could happen. Everybody we talked to scoffed at the idea to such an extent that I didn't believe anybody anymore. So it remains an open question.

MAGALETTA: The interesting thing is Powell's last paper in 1985, really confirms everything Dr. Fife did. And I've been hoping for a long time that that wasn't true.

LANPHIER: You're right. It was Powell in 1981.

FIFE: So the second paper was last year, wasn't it?

MAGALETTA: March of '85.

LANPHIER: I'll bet it is the same data, though.

FIFE: That may add a little more confusion to the problem though. Are there any other comments or questions? Sue?

BANGASSER: In Margie's experiment, her group that had the diving and had the abnormalities, once they --

LANPHIER: Well, this is a human survey now?

BANGASSER: It is a human survey now. Weren't they diving at a hundred feet or greater -- do you remember that? The 180 ft dive was the missing hand.

LANPHIER: One-hundred-sixty for one and 120 for the other. And I have honestly forgotten. There's another slide which maybe we should have seen. Could you turn the projector on again? Frequency of dives. This is Margie's table depth of dive. In the first trimester, 19.8% of her respondents dived in greater than 99 ft; the second, 12.2%, and in the third, 9.1%. But I don't know of any place where she tied that to the actual incidents. But there was quite a bit of deep diving going on in that group. And you can be sure that someone got away with it scot free. And we just don't even know for sure whether that was the reason for the problems or not.

FIFE: That is true. These are just guesses on their depths in some cases. Margie admitted it. She stated that some of these people did not have accurate depths gauged and some of them did not have accurate times. Am I correct about that? That's what I think I remembered her telling me.

LANPHIER: Well, even if I didn't remember anything about it, that's human nature, right? We can make that assumption no matter what they said.

FIFE: Right. That begins to soften the data.

LANPHIER: Well, if somebody says they were at 160 ft, you can be pretty sure that they were not at 60.

FIFE: Any other questions or comments?

VOICE: A couple questions and one comment. The question concerns the definition of women who were diving during their pregnancy versus not diving during pregnancy. I'm wondering how many of the ones who said they did not dive during pregnancy meant they did not dive after pregnancy was diagnosed. This could mean that they could have had a few dives in early pregnancy.

LANPHIER: I can't answer that question.

VOICE: Or, you know, if they hadn't been diving for the previous six months.

LANPHIER: But I think Margie was smart enough to have them date back their dives.

BANGASSER: I think she did.

LANPHIER: I don't remember a specific statement to that effect. But anything else would have been --

BANGASSER: She even had women report that when they found out they were pregnant and had been diving, and they went out and had abortions.

LANPHIER: Can I ask Sue a question? You did a beautiful survey. But it was much more global than just pregnancy.

BANGASSER: It was.

LANPHIER: But did you ask any embarrassing questions like their drinking habits, and smoking?

BANGASSER: No, I didn't ask any questions along those lines.

LANPHIER: I don't think Margie did either. And I don't think Betts did. But it just occurred to me that that might be the real -- apparently 5.5 is pretty high for the incidence in a group like this. I wish we had some good figures.

FIFE: It seems to me that also these deformities have got to be created early in pregnancy. Any diving these people did in late pregnancy would not have, for example, caused a missing hand -- or spina bifida. And the question is when during the course of pregnancy these deep dives took place? Did they take place all in their first trimester, for example? And I don't recall her data of bringing that point out. Do you?

LANPHIER: I don't either.

MAGALETTA: The loss of a hand could occur anytime during pregnancy. And one of the more frequent kinds of things that could cause this is in intra-amnionic bands that actually wrap around the limb -- and it falls off without infection, of course.

FIFE: But this is not a diving problem.

MAGALETTA: The other thing that we've seen over the years in Thalidomide from Germany. Of course, we don't have that now but there was a lot of that at that time.

BANGASSER: The survey was taken way after that period of time.

LANPHIER: Any kind of medication, let us say, might be significant. We just don't know.

HONG: Some years ago, Jim Metcalf at the University of Oregon, found that, when you hatched eggs in hypoxia, the weight of the newly hatched chick was a lot smaller than normal chicks. He then asked me if I knew of any studies showing that the babies of Amas are any smaller. I did some literature survey and found one Japanese study indicating that although statistically not significant, babies delivered by these Amas are slightly smaller than the average.

LANPHIER: Do you remember whether that was Harashima Iwasaki?

HONG: No. I do not remember.

LANPHIER: That was in the 1965 Ama symposium. Is there something more recent?

HONG: Yes.

LANPHIER: That makes two studies that say the same thing. Harashima said so sometime before 1965.

HONG: I think it's a potential issue.

LANPHIER: He was quoting some public health statistic.

HONG: Maybe that's the same one then. I just don't remember exactly.

MAGALETTA: I think both of those papers need to be put in context. Prematurity in the Harashima's article was 44.6 percent, as I recall, and the only parameter that was measured was birth weight.

HONG: Yes.

MAGALETTA: I think that anybody working the way the Ama divers work right up to the time of delivery and working harder than most people in this country ever think of working, you can depend on getting small for gestational age babies. And what that means is they actually are not premature, but they are small in comparison to the rest of the population. Also, I don't remember what population they were comparing. Whether it was Japanese, Korean, or Western.

FIFE: It was Japanese. I remember that.

LANPHIER: Yes. But whether the controls were hard working dry land women, or not, is the question, I guess. And they probably weren't.

MAGALETTA: I'm sorry?

LANPHIER: Whether they were hard working dry land women compared to the hard working underwater women is the issue.

HONG: There are methodological problems in this type of study and somebody should come out with a good design for an experiment. Then we may get the answer.

INNES: I just wanted to make one comment. I think it's excellent that we're doing these studies and that they're being done. I just wanted to make sort of a footnote comment that for those of you who are here who are instructors or practicing OB/GYNs, you'd be well advised from your attorneys to advise your clients not to dive. All you have to do is put one of these studies before a jury and you're sunk if your client had birth defects.

GREENBAUM: I'd like to point out that at the workshop that was held last week on Fitness to Dive, Dr. Armour, who in the diving medical officer for

the Smithsonian, gives all their female divers pregnancy tests before they dive. And if they're pregnant, they will not allow them to dive.

INNES: You just have to -- I think the controversy is very good. I just wanted those people who are instructors who get a patient that comes in, you can allow them, to a certain degree, to make their own decision. I think that's good. The comment I get a lot is, "I don't care. I read an article by Susan Bangasser. I read something and it's okay to dive." I don't teach them because I don't want to take the responsibility. If something happens or if they dive, then I'm going to get a cause of action from their husband or their mother or father.

LANPHIER: Is there any protection against that?

INNES: Insurance.

LANPHIER: Well, what I'm talking about, though, is something that I guess I actually wrote into my article on this whole thing, the Merke Manual, that if you examine a patient who seems to have decompression sickness and you think that individual should be treated and you're not entirely sure they're going to do that, to get a signed and witnessed statement from them acknowledging that you gave that advise. Now, is that at all helpful, or is it just another thing that isn't worth the paper it's written on?

INNES: Signed consent forms are useful in a lot of personal injury suits involving medical type problems but they are not foolproof. They are important but not foolproof.

LANPHIER: Could we have a statement that a pregnant prospective diver could sign acknowledging that the OB man or the instructor, whoever had responsibility for advising her, had said, "Don't dive"?

INNES: And they chose to voluntarily dive anyway, or at least to that effect?

LANPHIER: Yes.

INNES: Probably that would be very significant evidence in your defense to the jury, that they signed a consent release form, so to speak. However, the key issue, if I were the plaintiff's attorney, that I would bring up would be: Was she made aware of all of the knowledge available at that time to the doctor of all the risks? What about this 1985 survey? That's what I'd do if I were the plaintiff's attorney. And if you missed one of those, you've got to remember you're dealing with a baby that's missing a hand that's sitting there on the plaintiff's table throughout the trail. And you've got 12 people sitting there. You've got a problem. I think a consent form would help, but you've still got a problem.

LANPHIER: Twelve people who love to spend other people's money.

INNES: That's right. And that award isn't going to come out of their pockets. But I'm pointing out to you the problem. I think consent forms

have been proven time and time again that they have won many lawsuits or defended against many lawsuits. And the medical profession uses them on a regular basis now. You'd be crazy not to use them. I just want to point out nothing is foolproof when you've got a baby with a missing hand in front of the jury.

LANPHIER: It's worth more than the paper it's written on?

INNES: Oh, very definitely. Particularly if it is informed consent.

MAGALETTA: You know, there is another side of this issue and that is sport divers. We're not talking about the professional who has a chance of losing a livelihood or career, a big financial gain or loss.

We also have responsibility for that baby and I'm asking you this question. As researchers trying to get some answers, how are we going to get these answers unless we get some prospective studies. I'm trying to get some information on my own. Let me tell you what I say to my patients who tell me that they are divers and are pregnant. I say, "We don't want you to dive because we don't know whether it will cause damage to the baby or not. The human experience is not conclusive. The only information available says that the baby could be damaged. Therefore, you should not dive. But if you do dive, for God's sake let me know about it, and give me an accurate dive profile."

Now, can that be expanded into a nationwide picture so we could somehow do prospective studies on people who, in spite of the information we have, want to dive? Can we then use these people, hook them up to Dopplers after and before diving, and do some studies on endocrinology, and still maintain that we have given them adequate information to protect us legally?

INNES: Probably.

MAGALETTA: Probably.

INNES: I'll never give you the answer "no," but probably, "yes." Probably you would be safe doing that. And I believe I saw a request in a recent magazine I was reading asking for women who were pregnant who were diving who would want to participate in a survey.

They did this research with runners; they have done this for a long time. I've also been involved with fitness and running, people who wanted to be marathoners in their ninth month, and they did the same thing. They asked for people who were going to run anyway, "Would you participate in our survey?" And they've gotten a lot of good data on women in running from using that very method.

Probably you're safe. If they are aware, they're voluntarily participating in it, and they're at a certain educational level. I would feel the same way with the 18-year-old pregnant mother whose taking a sport

diving course and just says, "I don't care. I don't want to go to the doctor because it costs me 60 bucks to the doctor," or something like that.

But if you were doing it on the kind of study you were talking about, I think you'd be safe.

LANPHIER: You know, the Doppler question. I don't think you dare to use the Doppler on these people. That would be just asking for a suit.

MAGALETTA: Why do you say that?

LANPHIER: Because I think enough people -- there is enough in the literature -- questioning whether the Doppler causes problems or not.

MAGALETTA: In the diver or --

FIFE: He's probably thinking of the work we did in which the question was raised as to whether the Doppler caused the bubbles.

INNES: Of the mother.

LANPHIER: I'm thinking if the person has any degree of supersaturation and you use a Doppler on her, we don't know that this doesn't set something off. So I'm just throwing back to you the question you raised earlier. And Bill Fife has thought about it, but as far as I know nobody has done a really conclusive piece of work on that.

So you'd have to steer clear of any intervention that would add to the potential problem.

MAGALETTA: Let me ask both of you a question on sheep research. We always talk about death of the fetus and decompression sickness in the mother. I have never seen all of the results on what happens to the mother. Does the mother die from this decompression sickness or does she just have it? And the other question is do you ever recompress these mothers and then see what happens to the fetuses?

FIFE: Most of the time I recompressed them for humane reasons. When we would hear the bubbles in the fetus, we would usually let that be the sign for recompression.

Now the mother, when she gets the bends, she just raises one leg or the other and if you wait around awhile it tends to go away pretty soon and she's okay again. So I think the level of bends that we were getting in the mother would usually not have required recompression treatment.

But whenever we treated the fetus, in many cases, that baby, then, was later born normal. In fact, when they're delivered, we have to watch them because we have to cut the wire off because the transducer is still around the umbilical artery when they come out.

So we treat both of them. I don't know what you did in yours.

LANPHIER: Well, our study, these animals had very slight cases of decompression sickness. And in almost every case, I don't remember the details, but they recovered spontaneously, almost always; I don't recall that we treated a single one in that particular group. But a day or two or three later, there was this dead beautifully formed little lamb. So it was pretty impressive.

FIFE: Are there any other questions?

NUNNELEY: The women who choose to continue diving might also be taking other risks such as smoking and drinking alcohol. We can't stop these women from diving, but we can try to inform them. There's an analogy here with smoking and drinking alcohol, that there is an element of informed risk-taking.

BANGASSER: I just thought I'd comment on what you referred to several times, the dangers of treating the female diver in a chamber, and the elevated levels of oxygen. Isn't there a way to study treatment of pregnant women who were treated in the chamber for non-diving problems and note what happens?

FIFE: There's some work on that that's already been done. George Hart, for example, has treated a number, and he has not sees any problem at all with the baby after birth.
BANGASSER: I remember he commented on that.

FIFE: Yes. These women, one of them at least, had carbon monoxide poisoning and he treated her. And the other one, I think, had gangrene, gas gangrene. So at least I know of those two. And I understand he's treated four or five others without any apparent problems.

BANGASSER: Has he come out with any published articles on his findings?

FIFE: I haven't seen anything.

BANGASSER: It has all been personal communications.

FIFE: I tried to call him the day before yesterday to discuss it but he was out. So I couldn't get up-to-date on that.

BANGASSER: Okay.

LANPHIER: You have several things to worry about there. John Rankin had a proposal which was mainly aimed at the premature closure of the ductus arteriosus, to try to find just what oxygen pressure and duration, and so on, caused that to happen, and what the consequences were. But it was not funded. And then the other thing is the retrolental fibroplasia story.

FIFE: Well, I've taken sheep and given them daily dives for the 30 days before delivery, and had an ophthalmologist look at these, there were four animals, and he found no evidence of any eye abnormalities.

LANPHIER: And what kind of oxygen pressures did you have on the fetus?

FIFE: They took 60 ft dives on pure oxygen, the standard treatment that we give for gas gangrene, and so on. And there was no problem. Now apparently the trouble does come after birth in these animals. But before birth it just reduces the uterine artery flow which tends to prevent the baby from getting so much O_2.

MAGALETTA: The retrolental fibroplasia is a real problem. And it was more of a problem a few years ago before we started monitoring fetal oxygen levels, or newborn oxygen levels. If you want to easily find retrolental fibroplasia, use rabbits in your experiment because they're very sensitive to it. Most other animals, including sheep, are very resistant to this problem, for whatever that's worth. This raises the question of birth defects.

LANPHIER: Margie Bolton reported no stillbirths, but did report that 5.5% had birth defects.

MAGALETTA: Birth defects, okay. You're right. The zero percent was stillbirths.

NUNNELEY: There was another study which had zero birth defects.

MAGALETTA: In any case, the zero percent is the thing that makes her work most suspect because in the general population, there is no zero percent that it can compare to. It's much higher than that. And I think that's--

LANPHIER: Well, you talk about the general population. How about talking about this kind of a population that women divers come from.

MAGALETTA: I think that you have the same thing. I don't think zero represents that population either.

LANPHIER: I don't think it can either. But I don't know why that makes her study suspect, just because --

MAGALETTA: Well, I think what it means is that the numbers aren't big enough.

LANPHIER: Well, I agree.

MAGALETTA: The other thing in neural tube defects or the spina bifida that's mentioned. There's a 0.05 to 0.1 percent incidence with no family history. And with a family history you've got a 0.2 to 4.0 percent incidence in the general population. I don't know what that means. But I thought I would fill it in because it's getting to be a real problem as far as our obstetricians are concerned.

The last question that I have is what proof do we have of stillbirth in humans that have had decompression sickness? I don't think that we have any. The other dangers relating to the fetus in the treatment of decom-

pression sickness mentioned are retrolental fibroplasia and ductus closure. But I think almost anyone, who does any work with premature newborns has seen this. There is a real problem when excess O_2 is used. It might be worthwhile to take a survey of all operations of our chambers and see if they have any incidents of this.

The last two things I would like to comment on is the Russian literature. And there's a matter of 800 cases of women treated during pregnancy and delivering babies in chambers, and having no problems with the fetuses, or the newborn. I'll bring that up in my presentation and I'll show some slides on this. I can't get the full papers but this information came out in the International Hyperbaric Oxygen Society meetings in Moscow, I think, in 1980 or 1981. Do you remember that, Dr. Shilling?

SHILLING: Yes. I think it came out at that time.

MAGALETTA: It would be nice if we could get the full papers on that. I have tried unsuccessfully a number of times. Another source could be in England. In the beginning of the '50s, they were treating women with HBO during pregnancy for a number of different reasons, but suddenly stopped. And that information may be available. I don't know the person who did this.

BREATH-HOLD DIVING PATTERNS OF AMA: MALE VERSUS FEMALE

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There are perhaps millions of people in this world who are engaged in short, shallow breath-hold dives for recreation. On the other hand, there are many thousands of professional divers who dive to deeper depths for a longer period for certain underwater activities. The latter group includes Navy divers, male and female breath-hold divers of Korea and Japan (who will be collectively referred to as "Ama" in this presentation), male sponge divers in Greece, male pearl divers in the Tuamotu Archipelago, and many other commercial divers. These divers learned the art of diving through many years of hard training, in order to increase both the depth of diving and the bottom time with minimal risks.

Since 1959 I have been continuously engaged in studying the physiology of professional breath-hold divers of Korea and Japan. Although the major focus of these studies has been placed on Korean women divers, I have been able to conduct some limited studies on male divers of Japan in 1984-1985 in collaboration with Prof. Shiraki of the University of Occupational and Environmental Health, Japan. In this presentation, I will try to describe the diving pattern of women divers and, at the same time, will attempt to compare it with that of male divers where it is possible.

GENERAL DESCRIPTION OF AMA

There are more than 30,000 professional breath-hold divers along the coasts and islands of South Korea and Japan, who daily harvest the ocean floor gathering abalones, snails, sea urchins, and sea weeds. Although it has been impossible to trace the exact beginning of these divers, it is generally agreed that they may have been in existence for at least 2,000 years. One of the oldest Japanese references which refers to the Ama is believed to have been published in 268 B.C. Since there are many historical records indicating frequent migrations of divers between Korea and Japan, it is not clear whether the diving profession originated from one of these countries and spread to the other, or was initiated in both countries independent of each other. Regardless of the origin of these divers, the diving technique has been developed independently in each country and there are several major differences between Korean and Japanese divers (see below). In both countries, the Ama works in villages along the coast and belongs to local fisheries unions which collect and sell the products and establish local working conditions. While this profession belongs exclusively to females in Korea, in Japan, both males and females are engaged in diving work.

According to the statistics compiled in 1977 by the Ministry of Agriculture, Forestry and Fisheries of the Japanese government, there are approximately 13,000 full-time divers in Japan, of whom 8,500 (65%) are male; moreover, the number of male divers remained the same whereas that of

females decreased by 20% since 1965. It is also significant that male divers are responsible for 75% of the annual harvest by all divers in Japan. In general, the pattern of distribution of male and female Ama indicates that most of the male divers are located south of the 25°C August isotherm line while the female divers are located throughout the entire sea-coast of South Korea and islands of Honshu, Shikoku and Kyushu in Japan facing the Sea of Japan and the Pacific Ocean, regardless of the water temperature. It is noteworthy in this regard that most of the Japanese Ama (both male and female) are seasonal divers engaged in diving work only during warm seasons (typically from June through September) while the Korean Ama (all female and no male) dives throughout the year. Exactly when and why male divers in Korea disappeared from the scene are interesting questions but are totally unknown. There are descriptions of both male and female divers engaged in diving work in the same area in the literature published in the 17th century. There may be some cultural or physiological reasons for the disappearance of male divers in Korea since then, but it is beyond the scope of this chapter to speculate on these.

At the age of 11 to 12, boys and girls start to learn how to dive in shallow water (about 1 m in depth). When they become 17 to 18 years old, they develop into full-fledged divers and continue their profession until they get too old to dive. The oldest Ama brought to our attention was 92 years of age. Although many young women are actively engaged in daily diving work, there is no evidence for alterations of either menstrual cycle, sexual activity or marital status. It is also noted that the menstrual cycle does not interfere with their work. Moreover, at the time of pregnancy, they usually continue to work until the day of delivery, and rest only 5-10 days thereafter.

Traditional Ama used to dive wearing only light cotton bathing suits even in the mid-winter when the sea water temperature decreases to 10°C. Only recently (since 1977 in Korea), these divers were allowed by the local fisheries unions to wear wet suits (and fins).

BASIC DIVING PATTERN

Basically, two different diving techniques are used by the Ama (1). One is a simple system in which the diver operates alone; he/she is called "cachido" (unassisted diver). All Korean Ama and the majority of Japanese Ama (both sexes) are cachidos. The other is a more sophisticated technique; this diver, called a "funado" (assisted diver), has a helper in a boat. We find funado divers only in Japan. They are more experienced divers who start out as a cachido and then slowly develop into a funado at the peak of their diving profession. As they get older, they revert back to the cachido.

The cachidos operate from a small float at the surface. They take several deep breaths, then swim to the bottom, collect what they can find, and swim up to the float again. Since oxygen is consumed for their swimming effort, they are restricted to relatively shallow dives and a short time on the bottom. On the average, they limit their foraging to a depth of 5-6 m and each dive lasts about 30 s. Between two successive dives they hang on to the float and rest for about 30 s. Thus the cycle takes about a minute,

and the diver makes about 60 dives an hour.

The funados dispense with swimming effort and use aids that speed their descent and ascent. They carry a counter weight (about 13 kg) to pull them down to the bottom (where they release the counter weight and swim around to gather what they can find), and at the end of the dive helpers in a boat above pull the diver up with a rope. While the diver is resting by the boat between dives, the counter weight is also pulled up by a helper. These aids minimize their oxygen need, thereby enabling them to go to greater depths and spend more time on the bottom. The funado can work at depths of 20-30 m and average 30 s in gathering on the bottom - twice as long as the cachido. However, since the total duration of each dive and resting period is twice that of the cachido, the funado makes only about 30 dives an h instead of 60. Consequently, their bottom time per h is about the same as the cachido. Their advantage is that they can harvest deeper bottoms for longer times.

As stated above, the contemporary Ama wears wet suits (made of foam neoprene), and fins. Diving patterns of these wet-suits divers in Korea and Japan have been studied recently by Park et al. (2) and Shiraki et al. (3). As expected, contemporary divers use counter weights (3-5 kg) to compensate for the positive buoyancy of wet suit diving. However, the analysis of buoyancy-mass relationship at surface indicates that both male and female wet suit divers regulate the counter weight to maintain a slightly (3%) greater positive buoyancy force than when wearing the cotton suits. In fact, the actual counter weight is only about 40% of that required for neutral buoyancy. However, this slight positive buoyancy at surface decreases quickly once the diver starts a descent to the bottom during which both the lung volume and the neoprene suits are compressed. In fact, calculation indicates that a wet suit diver essentially achieves a neutral buoyancy at 10 m depth.

DIVING VELOCITY

The rates of descent and ascent have been determined in traditional and contemporary divers and the findings are summarized in Table 1. Traditional female cachidos wearing cotton bathing suits descend and ascend at the same velocity of approximately 0.6 m/s. The latter rate is slightly lower than the corresponding values of 0.7 - 0.8 m/s observed in the male counterpart. On the other hand, the diving velocities are approximately 2-fold greater in traditional female funados than in traditional cachidos of both sexes.

As stated above, contemporary divers wear wet suits and use fins. Although these divers use counter weights, they maintain at water surface a slightly greater positive buoyancy force than when wearing the cotton suit. In this connection, it is interesting to note that such an adjustment of counter weights in female wet suit cachido divers preserved the same descent rate (0.6 m/s) as the cotton suit cachidos, but increased the assent rate to 0.8 m/s (30% faster than the cotton suit cachidos). This selective increase in the rate of ascent is attributed to the combined positive buoyancy and the action of fins. On the other hand, male wet suit cachidos diving to deeper depths (10-20 m) are able to markedly increase the rate of descent to 1.1 m/s which is almost comparable to that achieved by traditional funado divers) but not that of ascent. This high rate of descent in male wet suit

TABLE 1

Diving velocities of cachido and funado divers.

Diver	Descent rate (m/s)	Ascent rate (m/s)	Diving depth (m)	Reference
Female				
Cachido-cotton suits	0.6	0.6	5-10	Hong et al. (1963)(6)
Cachido-wet suits (+ fins)	0.6	0.8	5-10	Park et al. (1983)(2)
Funado-cotton suits	1.2	1.4	10-20	Teruoka (1932)(7)
Male				
Cachido-swim suits	0.7	0.7	5-10	Shiraki et al. (1985)(3)
Cachido-swim suits	0.8	0.7	10-20	Shiraki et al. (1985)(3)
Cachido-wet suits (+ fins)	0.6	0.6	5-10	Shiraki et al. (1985)(3)
Cachido-wet suits (+fins)	1.1	0.8	10-20	Shiraki et al. (1985)(3)

divers is achieved by vigorous movements of arms and legs. However, diving velocities for shallow dives (5-10 m) are not different between swim suit and wet suit divers. In other words, male cachido divers selectively increase the rate of descent when they engage in a dive to deeper depths.

Based on the average dive time, surface time (resting time between two successive dives) and diving velocities, a general pattern of diving to 5 m depth is reconstructed for both male and female cachidos wearing wet suits and is shown in Table 2. On the average, the single dive time of 39 s in male divers is approximately 20% longer than that in female divers. Approximately 40% of this diving time is spent for descent and ascent, providing 23 s of the bottom time for male divers as compared to 16.5 s for female divers. Based on the number of dives per hour, the bottom time per hour of diving is estimated to be 17 min and 12 min, respectively, in male and female divers. Another gender difference is that the average single surface time is 10% shorter (despite the longer diving time) in males than

TABLE 2

Comparison of general pattern of diving to 5-m depth between male and female cachidos wearing wet suits.

	Male (3)	Female (2)
Single dive time, s	39 (100%)	32 (100%)
Time for descent, s	8 (20%)	9.2 (29%)
Time for ascent, s	8 (20%)	6.0 (19%)
Bottom time, s	23 (60%)	16.5 (52%)
Single surface time, s	42	46
No. of Dives/h	44.4	46.2

in females. These findings indicate that male divers are more efficient in that they have a 40% longer bottom time for a given diving time as compared to the female counterpart.

DAILY WORK SCHEDULE

That the human body cools faster in water than in air of the same temperature is well recognized. The main reasons for this are that the specific heat of water is 1,000 times, and thermoconductivity 25 times, greater than those of air. This direct loss of body heat to the surrounding water is the dominant thermal problem of the diver. The temperature of sea water in which the Korean Ama is engaged in daily diving is approximately 25°C in the middle of summer and 10°C in winter. This means that, even in summer, the water temperature is considerably lower than a thermoneutral level (34-35°C for average human subjects). Despite such a potential cold water stress to which the Ama is daily exposed the year round, she used to wear either light bathing suits made of cotton or a loin-cloth throughout a year, and thus her daily work schedule is largely dictated by the level of the sea water temperature. Only recently, has the Ama been allowed to wear wet suits to avoid the cold stress, which has led to significant alterations of the diving work pattern.

Traditional Cotton Suit Divers

On a typical summer day, the Korean Ama takes three shifts a day (one in the morning and two in the afternoon) each lasting approximately 40-60 min. Between shifts she returns to the shore to warm up by a fire for an hour or so until she starts sweating. On the other hand, she usually takes one to two shifts a day in the mid-winter; both shifts are taken in the afternoon and each shift lasts only 15-30 min. A linear relationship exists between the duration of a work shift and the sea water temperature (4), clearly indicating that the main factor limiting the duration of the work period is the cold water stress.

In order to define the thermal limit of working in cold water, the rectal temperature was measured in the Ama while engaged in usual diving work in water (5). After 5 min in water the rectal temperature decreased linearly despite the increased heat production as indicated by visible shivering (which is observed even in summer toward the end of the shift). When the rectal temperature is lowered to approximately 35°C (from 37°C before the shift), the Ama feels so cold that she can no longer continue her work and heads back to the shore to get warmed up. These findings indicate the rectal temperature of 35°C is the lowest limit of deep body temperature which can be endured by humans on a voluntary basis.

The oxygen consumption also increases markedly during the period of diving work in water (5). In summer, it increases 2-fold within 10 min in water, after which it continues to increase slightly until the end of the shift. In winter, the oxygen consumption increases 2.5-fold in 5-10 min in water and nearly 4-fold by the end of the shift. These results indicate that the body heat production increases during the period of diving work in both seasons, although the extent of the increase is much greater in winter than in summer as expected.

The total body heat loss during a work shift may be estimated from a sum of the amounts of the extra heat produced and of the stored heat lost. The former amounts to 94 kcal per 40 min shift in summer compared to 109 kcal per 25 min shift in winter. In other words, the rate of heat production is nearly 100% greater in winter than in summer. The amount of the stored heat loss amounts to 293 kcal per shift in summer and 466 kcal per shift in winter. Thus, the total heat loss per shift amounts to 387 kcal (= 94 + 293) and 575 kcal (= 109 + 466) in summer and winter, respectively.

Contemporary divers in both Korea and Japan have been wearing wet suits during the last 5-10 years and hence are not exposed to the severe cold water stress. In a series of field studies, these contemporary divers were asked to wear traditional cotton suits (Korean women divers) or swimming trunks (Japanese male divers) rather than usual wet suits so that thermal responses to cold water diving could be compared between male and female divers. The results are summarized in Table 3. Unfortunately, the sea water temperature was slightly colder for female divers (22.5°C) than for male divers (27°C), and therefore the results should be analyzed with caution. Both groups of subjects voluntarily tolerated 60 min of diving work in the sea, at which they complained of severe cold stress and terminated the diving work on their own. The average rectal temperature at the end of 60 min diving work was 35.0°C in Korean female divers as previously observed, but was 36.4°C in male divers. These observations suggest that the shivering threshold is considerably higher in female divers as compared to male divers. Moreover, there also was a difference in the body fat content (estimated from the subcutaneous fat thickness) between the two groups (~15% in the male and ~26% in the female), which in itself would provide and additional advantage to the female in combatting cold stress.

TABLE 3

Comparison of rectal temperature and heat exchange during diving work in summer between male and female divers wearing cotton suits.

		Male (8)	Female (9)
Sea water temperature	(°C)	27.0	22.5
Working time	(min)	60	60
Final rectal temperature	(°C)	36.4	35.0
Extra heat production	($kcal/m^2$)	125	50
Total heat debt	($kcal/m^2$)	85	159
Total extra heat loss	($kcal/m^2$)	210	209

Despite the nearly two-fold difference in the magnitude of the stored heat loss between the two groups, the total extra heat loss incurred during the 60 min diving work was identical at 210 $kcal/m^2$. This is due to the fact that male divers produced and lost far more metabolic heat during diving work than female divers. In other words, there is a difference in the behavioral (or physiological) aspect of thermoregulation in cold water between male and female divers. Female divers do not attempt to compensate for the rapid heat loss and instead tolerate a state of voluntary hypothermia in cold water. On the other hand, male divers try to counteract the rapid heat loss by markedly increasing the metabolic heat.

Contemporary Wet Suit Divers

Unlike traditional cotton suit divers, contemporary Korean women wet suit divers take only one long shift a day, 3 h in summer and 2 h in mid-winter. On the other hand, male wet suit divers take 2 long shifts a day (each lasting ~140 min) in summer and 3 short shifts a day (each lasting 80 min) in winter. Thus, the total working time per day is 50-100% longer in male than female divers. It is interesting to note that, as compared to traditional cotton suit women divers, contemporary wet suit divers greatly extended the working time in winter (from about 15-30 min to 120 min) by eliminating the cold stress.

In these wet suit divers, the rectal temperature decreases only slightly during long working periods in water. For instance, the rectal temperature decreases by -0.4°C by the end of a 2 h working period in summer when the sea water temperature is 22 - 27°C. Even in winter when the sea water temperature is 10 - 14°C, the rectal temperature decreases by 0.8°C in 90 min in male divers and by 0.6°C in 120 min in female divers. The mean skin temperature is also maintained at a more comfortable level of 32°C in

summer and 28°C even in winter. Moreover, the metabolic heat production during diving work increased only about 2-fold in both summer and in winter. Therefore, the thermal cost of diving is 60 - 120 kcal/m^2 per hour, which is 50-70% less than that estimated for cotton suit divers (Table 3). However, it should be recalled that the total working time per day is 2-4 h in wet suit divers and hence the total thermal cost per day in male divers is still as high as ~500 kcal/m^2. In other words, the divers are by no means completely protected from cold stress. In fact, male wet suit divers warmed themselves between shifts by a fire on the shore.

TABLE 4

A summary of daily diving time and extra energy cost in contemporary female and male wet suit divers.

	Female (9)		Male (8)	
	Summer	Winter	Summer	Winter
Water temperature (°C)	22.5	10	27	14
Working time (min/d)	180	120	276	240
Estimated bottom time (min/d)	37	30	69	60
Total extra energy cost (kcal/m^2 per d)	179	245	425	482

In Table 4, overall diving activity and energy costs of wet suit diving are summarized for comparison between male and female and between the summer and winter. As expected, the divers work longer hours in summer than in winter in both groups. More importantly, male divers are able to put in 50-100% longer working time than female divers regardless of the season. To carry out this physically demanding daily work load as well as to combat the cold water stress, male divers are daily paying twice as much energy bill as female divers.

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DISCUSSION FOLLOWING PRESENTATION BY DR. HONG

During the Second World War, the maximum breath-hold dives were about 30 m. As of 1985, the deepest breath-hold diving depth is 105 m. That's about 300 ft. It's a remarkable record. Now, Mr. Mayol went down to a depth of 105 m just last year. And this is a world record right now.

NUNNELEY: What was the theoretical limit supposed to be based on, residual volume?

HONG: Oh, that's way beyond --

FIFE: Six atmospheres (165 fsw).

HONG: Yes. That's way beyond that. In fact, I think that Dr. Lanphier and I agree that's reasonable -- what is the residual volume?

FIFE: About 1 liter in a normal male, but probably much more in Mayol.

KEY: Did any of these people complain of problems clearing their ears after

so many times diving in that cold water?

HONG: Well, they're so well trained, you see. They start training themselves from the time when they are only 11 years old and go in the shallow water. They practice that. So they don't much complain about it. Although when you look at the years of it you do find some medical problems with their ears. But remarkably, they are pain free.

MAGALETTA: Do you find that -- some of the divers dive to 20 ft and that's it. Some go to 30 ft, some go to 60 ft. That is not necessarily based on ability as it's based on need?

HONG: Mostly it depends on what they catch, what they find that day. Because after all, you know, they are commercial divers. They are after money. So wherever they can find it, they'll catch, and they go for it.

MAGALETTA: And it's not based on their physical ability to do that.

HONG: No.

MAGALETTA: Any one of them could go deeper?

HONG: I think so.

MAGALETTA: And that probably includes the male divers as well as the female divers.

HONG: That's right.

FIFE: What do you know, if anything, about the problems they're running into now that the women are using scuba gear? Has there been anything on that yet, such as the effects of diving on pregnancy?

HONG: No. In this area, scuba diving is not allowed.

FIFE: But I understand somewhere that there are some of these women that have now gone to scuba diving.

HONG: Yes. They are doing it illegally, secretly, but officially they're not allowed to.

FIFE: Well, is there any information on any problems they've come up with there?

HONG: No, no. In fact, I didn't make any inquiries in my frequent visits there. And I don't hear anything yet. But it has come up.

LANPHIER: Bill, where did you get the information they were using scuba?

FIFE: Well, I'm a member of a U.S.-Japanese Commission on exchange of technical information.

HONG: Yes. I belong to that too.

FIFE: And I was having a conversation with one of the Japanese at a recent meeting. He stated the Amas were using scuba.

HONG: Yes. There are some secrets.

FIFE: I didn't know it was a secret. I just assumed that,...

HONG: In fact, we're going to it ourselves. One of our subjects, a male diver, called up my colleague in Japan and he told him, "I'm in trouble because I was caught using scuba. So would you tell them that I did it for a study?"

INNES: Did they outlaw the scuba for conservation reasons?

HONG: Yes.

FIFE: In the Bahamas, it's the same way. You can't use scuba for spear fishing. Does anybody have any other questions? We're really indebted to you, Suk Ki. That's a very refreshing view.

HEAT, COLD, HARD WORK AND THE WOMAN DIVER

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The purpose of this paper is to review current knowledge regarding heat, cold and exercise effects on the woman diver. Fortunately, recent research has significantly increased our knowledge in these areas, while pioneering women have provided practical demonstrations of their capacity to work in physically stressful environments.

This review will be presented only in very general terms. Those interested in more detail should refer to the bibliography, which includes both reviews of the older literature and selected reports on recent research.

Historically, the characterization of human responses to stress was performed on men, and the male pattern came to be regarded as the human norm. When later studies on women revealed differences, it was easy to view these as evidence of female vulnerability to stress. Clear examples of this pattern of thinking can be found in the literature regarding work in hot environments. Early studies indicated that women were significantly less tolerant to these stresses than were men. We now realize that confounding factors invalidated the comparison between sexes. The subjects were "matched" in the sense that all were college students free of disease, but the men were fit and active, whereas the women's sedentary lifestyle left them with limited work capacity and no acclimatization to heat. More recent studies using better matched subjects show little sex difference in stress tolerance.

The general pattern of male-female differences is that of overlapping normal distributions, as diagrammed in Figure 1, where the variable depicted could be physical, physiological, or cultural (e.g. hair length). While the hypothetical average man and woman differ in a given characteristic, individuals will often fall within the range regarded as typical of the other sex. The actual form of the distribution often reflects both inborn and acquired components. For instance, the distributions for body fat shows the combined effects of inheritance, nutritional history, and prevailing attitudes concerning health and appearance.

In looking at the capabilities of women divers, we may formulate three relevant questions: 1. What work can she perform? 2. What are her tolerance limits? 3. What are her risks? Since the existing rules were written for men, the ultimate question becomes, "Must we make changes to accommodate women?" This has to be analyzed on two levels, as follows:

1. Training programs and safety guidelines for recreational divers should be based on characteristics of the general population, allowing margin for those who are least tolerant of stress.

2. Planning for women who make a career as commercial or scientific divers should be based on knowledge of performance capacity and stress tolerance in carefully selected, highly trained individuals.

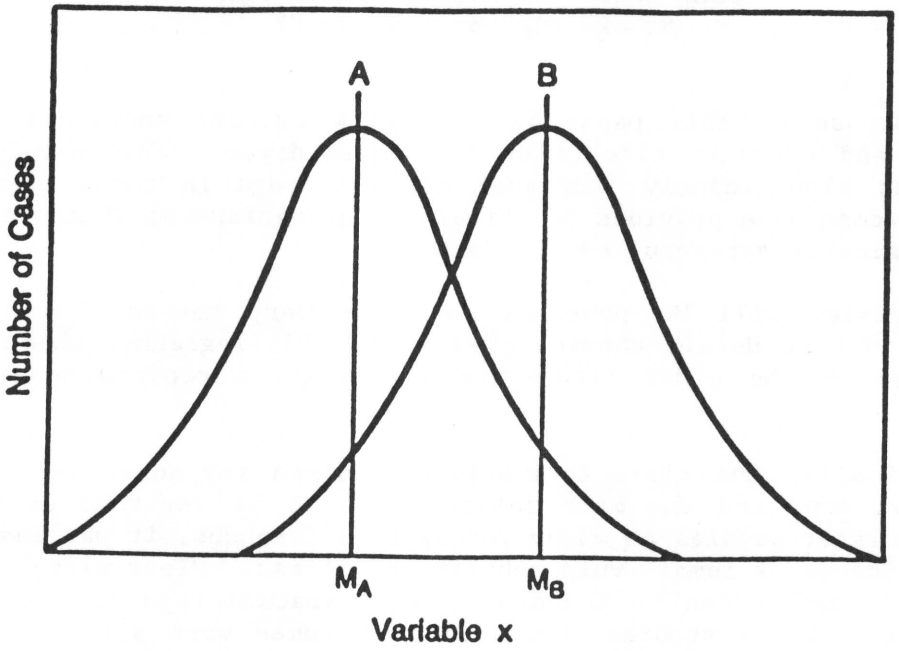

Fig. 1. Typical distribution of a variable in male and female populations. Height and width of each curve and amount of overlap depend on the specific variable involved.

RECREATIONAL DIVER

The goal here is to develop operating procedures which allow adequate safety margins for the full spectrum of individuals in the normal, healthy population. Table 1 shows the physical characteristics of average young, healthy men and women in the United States. The typical woman is relatively short in stature, light in weight, and has less muscle and more fat than does a male. She also has more subcutaneous fat.

The physical characteristics have several implications regarding tolerance for thermally stressful environments. It is said that small individuals of either sex may be at a slight disadvantage in an extremely hot or cold environment due to their surface-to-volume ratio, but Table 1 shows that the male-female difference in S:V is really very small. More to the point, a small muscle mass is a disadvantage in cold because it can generate less heat through exercise or shivering. On the other hand, subcutaneous fat is an excellent defense against cold. Contrary to popular belief, fatness per se has negligible effect on heat tolerance.

There has been speculation that women's higher fat content might increase their susceptibility to decompression sickness. Two retrospective studies of altitude exposures supported this idea, but the studies had serious flaws. Later experimental work has shown no significant sex

TABLE 1

Characteristics of Average Young Adults (U.S.) From Various Sources.

	Male	Female	F:M (%)
Height (cm)	172	162	94
Weight (kg)	67	55	82
Surface:Volume (cm^2/kg)	269	282	104
Lean Body Mass (kg)	57	40	70
Fat Content (%)	15	27	180
VO^2 max (L/min)	2.7	1.7	63
VO^2 max (L/mi kg BW)	40	30	75

difference, and there is no evidence of difference in response to diving and/or hyperbaric decompression schedules. Studies which rely on subjective symptomatology will always remain suspect in any case, since male and female subject have such different backgrounds with respect to self-image and response to pain. Women should use decompression tables in the same conservative manner which is advisable for men.

Physiological measurements show that the typical woman has a low aerobic capacity whether that is expressed as an absolute value or per unit body weight. She is also relatively slow to begin sweating and has a lower maximal sweat rate than does her male counterpart. Her muscle strength is significantly lower than the male's, particularly in the arms and shoulders. For all the these reasons, a fixed work load which is suited to a man may well push a woman into hyperventilation or exhaustion, with serious consequences under water. Remember that to a large extent these traits are not directly related to sex, but are secondary to small size and soft living.

PROFESSIONAL DIVER

In women who make a career of diving, the focus shifts from statistical description to examination of the maximal capacities of select, highly trained individuals. Women can benefit substantially from weight training regimens to increase upper body strength; while females do not develop the same absolute strength as do males, this appears to be a matter of minor importance in work under water. Women do not normally show the increase in muscle bulk which accompanies training in males.

Adaptation to aerobic exercise and thermal stress are virtually the same in both sexes. Table 2 shows data on body composition and aerobic capacity of elite athletes from three sports, indicating that much of the

TABLE 2

Characteristics of Elite Male and Female Athletes with Equivalent Training, Measured in the same Laboratory (after Drinkwater).

		Body Fat (%)	Maximal Oxygen Uptake (L/min)	(ml/minKBW)	(ml/min LBW)
Nordic Ski	M	10.2	5.42	78.3	89.8
	F	21.8	4.03	68.2	86.4
Distance Run	M	11.4	4.31	61.7	69.8
	F	18.9	2.82	55.7	68.9
Volleyball	M	12.0	4.80	56.1	63.8
	F	17.9	3.57	50.6	61.6

alleged sex difference is erased when male-female comparisons are made under optimal conditions.

Aerobic capacity is now commonly expressed per unit lean body mass, but serious problems are inherent in this approach because of the assumptions used in calculating body composition. Usually, body density is estimated by underwater weighing or derivative methods, and an equation is then used to determine fat and lean components; although there are several such equations produced by various investigators, each assumes constant density for muscle and for bone and a fixed ratio of mass between the two, regardless of age, sex, or physical condition. Calculated body fat is always higher in women than in men of comparable appearance, a fact which is generally attributed to the existence of more internal "essential fat" in women (see Behnke and Wilmore). Reexamination of the entire field is now in progress using new measurement techniques such as nuclear magnetic resonance. In any case, it should be remembered that body fat is a burden only during locomotion, has no effect on work load under water, and provides insulation from cold.

Recent studies on responses for men and women to thermal stress indicate that they acclimatize in exactly the same manner and are equally tolerant of thermal stress when allowance is made for previous conditioning. Women typically sweat less than men but enough to control core temperature, and men may have a slight disadvantage in that excessive sweating leads to dehydration.

HORMONE EFFECTS NEGLIGIBLE

Discussion of women's response to stress invariably brings up "the hormone question," usually with the hidden presumption that female hormones impair stress tolerance either continuously or at some specific time during

the cycle. Nevertheless, studies of healthy, active women indicate that the changes associated with their hormone cycle are negligible. For instance, the 0.5°C rise in basal temperature with ovulation has no detectable effect on heat tolerance or physical capacity. Alleged cyclic water retention is not documented in the literature; no changes in weight or body dimensions were found in a recent study of women who complained of monthly "bloating" (see paper by Faratian et al.). Severe dysmenorrhea or "premenstrual syndrome" (the latter a catch-all term) may be disqualifying problems, but they place the victims outside the normal population under discussion here; the same would be true for a seizure disorder in either sex.

A reciprocal question must be asked: Does chronic stress of the type encountered in diving disrupt the female cycle? The answer appears to be "no." Women who engage in regular, heavy aerobic exercise may develop oligo-amenorrhea, but studies of women athletes indicate that this syndrome is far more common in distance runners than in competitive swimmers. Divers are unlikely to engage in the extreme levels of exercise which are associated with this effect.

RESEARCH PROSPECTS

Certainly some areas remain for further exploration. We have not fully explained the small but persistent residual sex difference in peak aerobic capacity. We need a thorough reanalysis of body composition techniques for both laboratory studies and field applications. We also need to know more about the distribution of body fat in subcutaneous tissue and elsewhere in the body. Very little is known of the effects of pregnancy on responses to exercise and thermal stress as well as the specific hyperbaric aspects of diving. Related questions regarding possible serious adverse effects of diving on a fetus will be discussed by others in this workshop.

SOME CONCLUDING THOUGHTS

Hopefully future research will avoid the past errors such as the following:

1. Uncritical citation of older literature
2. Comparison of male and female data from different studies
3. Inclusion of confounding factors
4. Proliferation of purely descriptive studies
5. Shotgun studies of the menstrual cycle which lack any hypothesis as to why hormones might have an effect
6. Studies of the menstrual cycle which fail to adequately document the hormone status of subjects
7. Inappropriate titling of papers (e.g. "Effect of sex on..." when no effect was found)

Returning to the three original questions regarding the capacity of women divers, the following conclusions seem to emerge: 1. The average woman entering recreational diving probably will not be able to match male performance with respect to tolerance of unfamiliar stresses. On the other hand, she can find great rewards in recreational diving and can expect to improve greatly with systematic training, as is described for the elite diver. 2. For the professional woman diver, individual characteristics and capabilities are far more important than are alleged gender characteristics. Adaptability to stress is not sex-specific, and informed risk taking is a prerogative of both sexes. One unique area of concern for women divers revolves around their potential for pregnancy. The altered physical and physiological state during gestation may affect the woman's response to the stresses of diving; more importantly, diving may place the fetus at risk. These possibilities are covered elsewhere in this workshop.

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DISCUSSION FOLLOWING PRESENTATION BY DR. NUNNELEY

BANGASSER: I've been diving awhile in the Midwest and California. I have observed a lot of women do cold water scuba diving. On dive boats, you have not only the problem of getting cold in the water, but also of getting chilled in between dives while on the surface in a wet suit. There was one study done that I have quoted, and I would like your opinion on it. It showed that the ratio of surface area to body mass was significant in the cooling response. Comparing a male and female of the same basic size, the male would have more body mass and that leads to a greater source of warmth.

NUNNELEY: It is a factor. The surface to volume and surface to mass ratio is higher for the woman. She, therefore, has less heat-generation, and a greater surface through which to lose it. But the effect is very small.

BANGASSER: Another thing. Richard Long from OUI gave a paper at the IQ conference last year in November on temperature regulation. He found that men might stay warmer underwater because greater muscle mass generates more heat. Have you seen anything on this topic?

NUNNELEY: Unless you're going to say that all men who weigh lass than 60 kilos shouldn't dive or should be regarded as cold risks, why should you pick on women?

BANGASSER: Well, if you don't pick on women, would you think greater muscle mass would be a key factor in thermal comfort?

NUNNELEY: I think it's one among several contributing factors. But if you're talking about typical people again, the guy is going to have more muscle mass and the woman is going to have more subcutaneous fat. So it's probably going to come out more or less even.

MAGALETTA: I don't know if you mentioned this or not, but the heat tolerance, women sweat later and not as profusely.

NUNNELEY: If they're acclimatized, there is no difference between the sexes. It's the same.

MAGALETTA: Don't women have 2 to 3 percent less sweat glands?

NUNNELEY: That's controversial. If you read the different studies, some of them say more sweat glands and some say less. In terms of overall sweat rate per unit of surface area, it comes out just about the same.

MAGALETTA: Even though the surface area is larger, it would be the same?

NUNNELEY: Yes.

MAGALETTA: All right. The point I was going to make is they may sweat less, but they also conserve fluid better which gives them a better tolerance in the long run all around.

NUNNELEY: Yes.

MAGALETTA: And I think the proof of that was in one of the marathons in Montreal when they had the fall marathon and they had a sudden increase--unseasonable increase in temperature. Of the 50 heat strokes or heat problems that arose there was only one of the 50 that was female.

NUNNELEY: Women runners are probably a little better at listening to their bodies, whereas the men are going to make their personal best, regardless.

FIFE: Talking about the underwater weight, to determine ratio of fat to lean body mass, has anybody done a study on the diving Amas? These women, in the middle of winter, have got only 1 or 2 milliliters of fat under the skin. I think you said that, didn't you, Suk Ki?

HONG: Yes.

FIFE: Has there been any ...

NUNNELEY: The ones in the photographs don't look plump.

FIFE: Okay.

HONG: This is a complex issue. According to our analysis, women divers who dive all year around do balance their caloric intake -- heat loss.

NUNNELEY: What kind of calorie intake do they have?

HONG: Oh, something like 1000 calories of food per day just to make up the heat loss in Korean divers. However, the Japanese divers are seasonal divers. They dive only during 4 months out of the year so they pick up fat in the off season and lose it during the diving season. They don't balance out. They lose the body weight, the body fat which they may recover later on during the off season. So in these groups of divers we see different patterns.

FIFE: Well, I was wondering if they have a way of solving this question of measuring the lean body mass in females since this equation that you talked about earlier is not valid for women.

NUNNELELY: What is really needed is a direct tissue analysis.

FIFE: Does anybody else have any questions?

McGEEHEN: I'm in research at the University of Virginia. And I've been involved with the program for about 10 years. I agree with what you said. In the beginning, I thought I saw a difference in your male solution and our female solutions. Later on, I didn't see the difference. And later, I thought I did. And I see the same conclusions. As far as being less physically fit, they get cold faster, less mechanically adept, none of these seem to be a difference.

It did seem that women approached the task more slowly, a little more consciously. But they learn as fast or faster and are more open about their anxieties and about whether they're cold or not. So it's a little difficult to tell. They're not more dependent than their male counterparts. And they seem to be good or even better divers, student divers, than their male counterparts. But there's not much significant difference. And physically or psychologically, I really have not seen a difference over the past 10 years. This year we taught 60 students a semester, about 50 percent are female.

MAGALETTA: For the record, I'd like to say I agree with everything you said except one. I think you're a little bit too easy on the males.

NUNNELEY: What is the physical work? Is it upper body, turning a wrench, holding a welding ring kinds of things?

KEY: Well, it depends on the specific task. But there are ways to get around things. If you're putting a clamp together and you've got a big pneumatic wrench, you don't have to hold it up. You can put a milk jug on it and let it just be there and all you do is guide it. So there are a lot of little tricks of the trade.

NUNNELEY: When you measure muscle strength, women are equal to men in the hip flexure area, only slightly lower in the leg muscles, especially if they're trained. But the upper body ...

KEY: Well, the beauty of working underwater is you use your legs and your arms and you're more maneuverable.

NUNNELEY: And the same thing is true for work in space. But there you face the question of pre-breathing and bends susceptibility.

INNES: That was going to be my question. In everything I've ever read about bends susceptibility, it has always indicated that the females are more susceptible. But it was always based on lean body mass. And if all that comes into question, then it would seem that if everything that's based on that theory is wrong well, then, everything else is also.

FIFE: Let me give you a statistic on that. We have George Bass and his underwater archeology group at Texas A&M. I talked with him the other day

and he said that to date they have had over 30,000 decompression dives. Right now they're working at 160 feet with two dives a day for everybody that's diving.

About 25 to 30 percent of their divers are women. They've had, in 15 years, only three cases of decompression sickness. And all of them were in men. So the women, certainly in that record, are doing very, very well.

Are there any questions?

BANGASSER: How long did you say it would take a woman to get acclimatized to heat?

NUNNELEY: If you start at zero, the standard is--work plus heat stress for about two hours a day for about 10 days. But people who are physically fit have a head start. In the first place, their fitness regimen makes them partly acclimatized. And secondly, their cardiovascular system makes them progress a little faster. So if you are physically fit to start with, probably you would have a week or more to do it. But the major changes occur in the first 3 days.

In the old studies, the women were at ground zero and the men tended to be somewhere up the ladder already.

UIHLEIN: I'm particularly interested in hypothermia and heat stress and I know a lot of women divers. The men will be in shorties and the women would be in practically a dry suit quite often.

NUNNELEY: This shows that the women are smarter.

UIHLEIN: Have you come up with any diet study that might follow that and would tend to shift people into one area or out of it?

NUNNELEY: You mean in terms of better or same metabolic heat production, or something like that?

UIHLEIN: Yes.

NUNNELEY: Well, certainly, the business of keeping your intake up to match your stresses is worthwhile. You might want to shift towards more fats in your diet, I suppose, if you're under high stress. You could take enough thyroid to jazz up your system.

FIFE: Dr. Magaletta will be discussing hormones later.

NUNNELEY: It is interesting to consider Renaud's phenomenon (a disease which causes a major constriction of the capillaries in limbs. This can result in a reduction of blood flow so severe as to result in gangrene. Ed.) because it makes such people more susceptible to frost bite. And I'm wondering whether it also makes these people more susceptible to non--freezing injury in prolonged diving situations in which they are staying wet and constricted and chilly.

PSYCHOLOGICAL CHARACTERISTICS OF THE FEMALE DIVER

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In my talk this morning I am going to explain how I became involved in this particular area of research. I will describe what we have done during the past year, and I will comment briefly on what we plan to do in the year to come. I will also discuss the analog between problems that firefighters encounter when wearing self-contained breathing apparatus (SCBA) and those experienced by divers wearing Scuba. Not only are SCBA-Scuba problems similar, but many firefighters are also divers who serve on diving rescue crews.

Several years ago I presented a paper at the International Respirator Workshop sponsored by NIOSH, and when I finished describing our work with firefighters, a French psychologist, stated "the SCBA problems you have described are exactly what occurs in scuba divers." He went on to say, "I have worked with Jacques Cousteau, and we have attempted to control this problem by training divers to control panic and so forth." He also indicated that relaxation training had been found to be effective in conserving the use of a diver's air supply. As soon as I returned to campus, I reviewed this discussion with Dr. Lanphier, and we began to talk about several research possibilities. These discussions led to a pilot study, and I will summarize this work.

My talk will focus on the psychological aspects of diving because that is the perspective that I have been asked to adopt. I really think that the problem is a complex psychobiological issue, and that is how we are approaching the study of this problem. I am going to focus primarily on the psychology of this issue, however.

Our initial work involved problems encountered by firefighters (1-3). Of course, when individuals are required to exercise at high intensity levels, and there is stress of various kinds involved, either on land or underwater, there is a potential for complications and problems.

Firefighters are sometimes found dead or unconscious with their mask off, and when the equipment is tested it is found to be functional. In some cases, there is not only nothing wrong with the equipment, but the tank has air in it. The explanation that is offered in these cases is that a sensation of suffocation or claustrophobia develops, and the individual removes his/her mask because they feel that they are not getting enough air (1). Of course, if they happen to be in a toxic environment, they are often unconscious or dead within a short period of time.

Part of the problem involves anxiety. Research by Kellerman and his associates (4) has shown that a progressive increase in workload is accompanied by a linear increase in ventilatory minute volume. Once heavy work loads are reached, however, a hyperventilatory response is observed.

The anxiety neurotics in the study by Kellerman et al (4) differed from normals. At very light work loads (e.g., 50 w), their ventilatory minute volume was 20 liters per m higher than that of the normals. The ventilation of the anxiety neurotics was double what it should have been at 50 w. In other word, the anxiety neurotics were characterized by hyperventilation during light exercise. It is our belief that elevated anxiety in these individuals causes them to overbreathe and the hyperventilation then produces symptoms such as paresthesia, carpopedal spasms, tetany, and perhaps unconsciousness or convulsions resembling grand mal or petit mal seizures.

In the workshop (5) dealing with unconsciousness in the diver mentioned earlier by Dr. Lanphier, a number of speakers, primarily those from Europe, talked a great deal about hyperventilation in divers. Of course, there is also the possibility of hypoventilation, and the resulting CO_2 retention that Dr. Lanphier has described.

In our research (2,3) we have exercised healthy men and women on the treadmill at maximal and supra-maximal levels while wearing SCBA. This protocol should theoretically provide a sensation of inadequate air supply in some individuals. In point of fact, our research has shown that some individuals will actually remove their masks during this procedure. Imagine for a moment that you are exercising at a very high ventilatory rate of 100 to 125 liters per min, and a technician inadvertently turns the inlet valve the wrong way with the result that your air supply is suddenly cut off. You would experience an immediate sensation of suffocation, and you would remove your mask. There is evidence that some individuals experience peak flow rates that exceed the delivery capacity of SCBA during heavy work, and this can occur in normal individuals as well as anxiety neurotics. In other words, there is sometimes an objective basis for the sensation of inadequate air supply.

We have tested individuals psychologically and followed this testing with maximal treadmill exercise in collaboration with Dr. Peter Raven at the Texas College of Osteopathic Medicine in Fort Worth. We predict which individuals will have respiratory distress before they are actually tested. We then exchange sealed envelopes. My envelope contains predictions of those individuals who will experience respiratory distress during the treadmill test. Dr. Raven and his associates have reviewed each individual's response, and they identify the reasons for stopping. Some stop because of leg fatigue, some stop because of general body fatigue, and others stop because they can't get enough air (i.e., respiratory distress). Thus, the predictions are independent, and we evaluate whether or not it is possible to predict who will experience respiratory distress before it actually occurs. While we have employed a number of psychological variables, the strongest predictor variable has been found to be trait anxiety (2).

In our research individuals have been asked to rate their perceived breathing at 35, 50, and 63% of $\dot{V}O_2$ max under a control and a mask condition. It was found that breathing distress was higher at each workload for the mask condition. These findings indicate that use of a standard

mouthpiece, or a mask, produces a perturbation that accentuates respiratory sensation. This finding applies to normal individuals performing exercise at intensities ranging from light to moderate, and we have observed that perception of breathing during exercise at 35% of $\dot{V}O_2$ max is higher at every minute under the mask condition.

Incidentally, the "control" condition in this research has involved a trial in which a mouthpiece and noseclip were compared to a mask condition. If the mouthpiece and noseclip are removed, the rate of breathing is reduced below this "control" condition. In other words, perceptual effects were produced with both the mask and the standard mouthpiece.

In another experiment, test subjects exercised at maximum levels under control, mouthpiece, and mask conditions. The performance time in this particular test was reduced 6% under the mouthpiece condition and 11% with the mask. In other words, maximal exercise tolerance was clearly affected with both perturbations.

In our next experiment (6) the subjects exercised at 70% of $\dot{V}O_2$ max until they could no longer continue. The mean performance time was 67.3 min for the mouthpiece condition compared with 48.9 min for the mask. In other words, there was a performance decrement of 27% for the mask condition.

One option would be to not wear the mask, but that would obviously not be an effective solution. In other words, the diver or firefighter must rely on the Scuba or SCBA in order to function. This issue represents a classic person-machine problem.

The psychological prediction model analyzed in the SCBA research was quite effective in predicting actual distress in those individuals who experienced respiratory distress. It was possible to predict (blindly) five of the six individuals who would have distress before they actually experienced distress. There were 39 individuals who did not experience distress, and the predictions were accurate in 38 of the 39 cases. In other words, there was one false positive and one false negative since we predicted that one person would not have respiratory distress, and that person did; whereas another individual did not, but the prediction was that he or she would. The overall hit rate was 83% in that five of the six individuals who experienced respiratory distress were accurately predicted.

When we started our research with divers, we had already collected psychological data on approximately 1500 active sportspersons. This work represented different sports such as swimming, fencing, tennis, wrestling, hockey, track, gymnastics and so on, but not divers. We located an extensive literature involving divers, but much of this literature was anecdotal or speculative, relative to whether or not divers resemble or differ from other sport groups (7).

The various sport groups we have studied have been observed to differ substantially in selected cases. The divers we have worked with in our national study fall at the geometric centroid of the distribution previously described for athletes in general (7). Most of the other sport groups fall

within one standard deviation of the center of this distribution.

At the time we started our work with divers we had no idea where they would be positioned in this distribution. Also, unsuccessful candidates for Olympic teams, for instance, frequently fall in the left field or quadrant of the distribution, that is, they tend to score high on neuroticism and introversion. Successful candidates, on the other hand, often fall in the lower righthand quadrant. In other words, by comparison the successful candidates tend to be extroverted and stable.

Our work with divers has involved several approaches. First, we attempted to psychologically characterize divers here in the United States. Divers were recruited by placing a notice in *Underwater USA*, and within several weeks we had about 200 volunteers. For example, we eventually had to terminate the survey because our concern with potential intervening historical events. As one collects data in a questionnaire study of this type, it is possible that changes may begin to take place in the population being studied. As a matter of fact, in some of our earlier work with distance runners we found that results of our first report influenced the response of subsequent responders. In addition to the psychological characterization of divers, a secondary purpose of this survey was to evaluate whether or not gender differences exist. Of the 245 divers in our national study, 29% are females and 71% are males. These proportions match reasonably well with other epidemiologic studies involving scuba divers.

From a descriptive standpoint the men and women in our study are remarkably similar in almost every respect, but I will also talk about some ways in which there are differences as well. The age and educational backgrounds of the male and female divers in our study did not differ. Diving experience, measured in years, was higher in the males, but this difference was not significant. Also, the total number of dives was higher in the males, but the difference was not significant owing to the large standard deviations.

We also evaluated the proportion of salt water dives, fresh water dives, ice dives, wreck dives, low visibility dives and cave dives. The men and women were found to be the same in every case with two exceptions. The two cases where there were differences involved cave and ice diving, and the male divers had significantly more of each during the past year. These findings may not necessarily be characteristic of men and women throughout the sport, nor for those in the commercial and military sectors, and it would be desirable to replicate these observations.

Based upon interviews with a number of experienced divers, we decided that a possible measure of sensation seeking or risk taking behavior would be the average post-dive air supply (i.e., PSI). In our survey, divers were asked to consult their diving logs in order to retrieve this information, or to recall typical post-dive PSIs if logs were not kept. We found that the usual post-dive values were about the same in male and female divers, but the variability was substantial in both groups. The lowest post-dive PSI across each diver's entire history was lower in the males, but this difference was not significant. Male and female divers did not differ signif-

icantly for average dive depth and while the maximum dive depth was higher in males, this difference was not significant. It should be remembered that these are average values based upon recall and/or retrieval from the diver's log.

One of the design factors that we were cautioned about by reviewers when we submitted our original Sea Grant proposal involved the view that we would probably not find reports of panic behavior in experienced divers. The argument was that people who have trouble with panic behavior and anxiety states while diving usually quit diving (i.e., self-selection). We initiated this project with concern about this potential problem. We asked the respondents to indicate whether or not, in their own view, they had experienced what they would regard as panic or near-panic behavior on one or more occasions. There is a great deal of debate relative to exactly what panic behavior involves, and this is one of the reasons why we used an open-ended question. Employing this approach we observed reports of panic behavior in 54% of these experienced divers. We also asked the divers to indicate whether or not, in their view, the panic attack (or the near-panic behavior) they experienced, was of a life-threatening nature. Respondents answered yes or no to this question, and 44% perceived the situation as life threatening.

We also asked the divers to describe the incident. They were asked to refer to their logs again and enter the date, time, water temperature, air temperature, depth, type of dive (e.g., cave, wreck, ice) and anything they felt was relevant. In other words, a narrative was presented explaining what had occurred in as much detail as possible.

Inspection of these narratives revealed that independent raters agreed that there was or was not, an objective basis for the self-reported panic. For example, one diver was diving in a familiar area that he visited each year on vacation and it was something he always looked forward to. Suddenly, he was confronted by a shark. In this case, the diver would proceed to describe exactly what happened to him or her in that particular situation; that is, how they behaved, perceived stress, and so forth.

The question of whether or not a gender difference existed in panic behavior and perceived threat is a complex issue. This is one of the areas that we are continuing to study. Preliminary results revealed that 64% of the females experienced panic versus 50% of the males, but this difference of 14% was not statistically significant. Also, the females viewed the situation as life-threatening in 35% of the cases versus 48% for the males. In other words, there was more panic in the females and more threat in the males. While these differences were not significant, we are still working on the meaning of this interaction.

The questionnaires we used in our study are transparent. It is obvious on a measure of tension, for example, that the individual is rating whether or not he or she is calm (e.g., not at all, somewhat, moderately so, very much so). The individual who indicates that he or she is "not at all calm" scores on the tension anchor of this scale. This is an example of a single item taken from one of the six questionnaires used in our study. This

particular item is contained in a scale that consists of 40 items. Some of the other questionnaires have yes/no or true/false formats. We also employed a conformity or lie scale, and this was built into one of the instruments in order that we could control for response distortion.

In earlier work with world-class athletes in sports such as distance running, wrestling, swimming and men's and women's national and Olympic teams in running and rowing, a unique psychological profile was identified, and it was termed the "iceberg" profile (8). These elite athletes were observed to score below the population average on negative factors such as tension, depression, fatigue, and confusion but they scored significantly higher on psychic vigor. This pattern was termed the "iceberg" profile because all of the negative variables fell below the "surface" whereas the one positive factor (vigor) fell above the population average. This finding has consistently been observed in various groups of elite athletes, and it is depicted in Figure 1.

It also turns out, however, that some individuals have inverse profiles. They have an inverted "iceberg" profile, and when this is observed in an individual chronically, or in an individual who previously had an "iceberg" profile, a decrease in physical performance is noted. A person with an inverted "iceberg" profile would theoretically be at greater risk from a health and safety standpoint than would an individual with an "iceberg" profile. This prediction is based upon a mental health model that has been developed and tested with various sport groups (8).

The male and female divers in our national study were noted to possess the "iceberg" profile. Also, these men and women divers were more alike than unlike. As a matter of fact, their psychometric profiles were found to be remarkably similar. This is a significant finding from a number of standpoints. First, the profile is characteristic of the physically active individual. It doesn't seem to make any difference which sport group we evaluate, physically active individuals are characterized by the "iceberg" profile. Second, the incidence of depression and anxiety in the adult female population is significantly higher than that observed in the male population. This applies to almost any epidemiological study one considers. This does not apply, however, when comparisons of active men and women are made.

The Metropolitan Life Foundation has summarized data relating to office visits to physicians where the primary presenting symptom was psychological in nature (i.e., mental disorders). The report reveals that males and females do not differ through the first 25 years, but the incidence for females exceeds that of the males for every data point beyond the third decade. There is a continuing debate in psychiatry and psychology as to whether or not there is, in fact, a difference in the incidence per se, or whether there is merely a difference in the frequency of reporting and seeking support. Nevertheless, the finding reported in the Metropolitan Life Study is consistent across many epidemiological studies. These

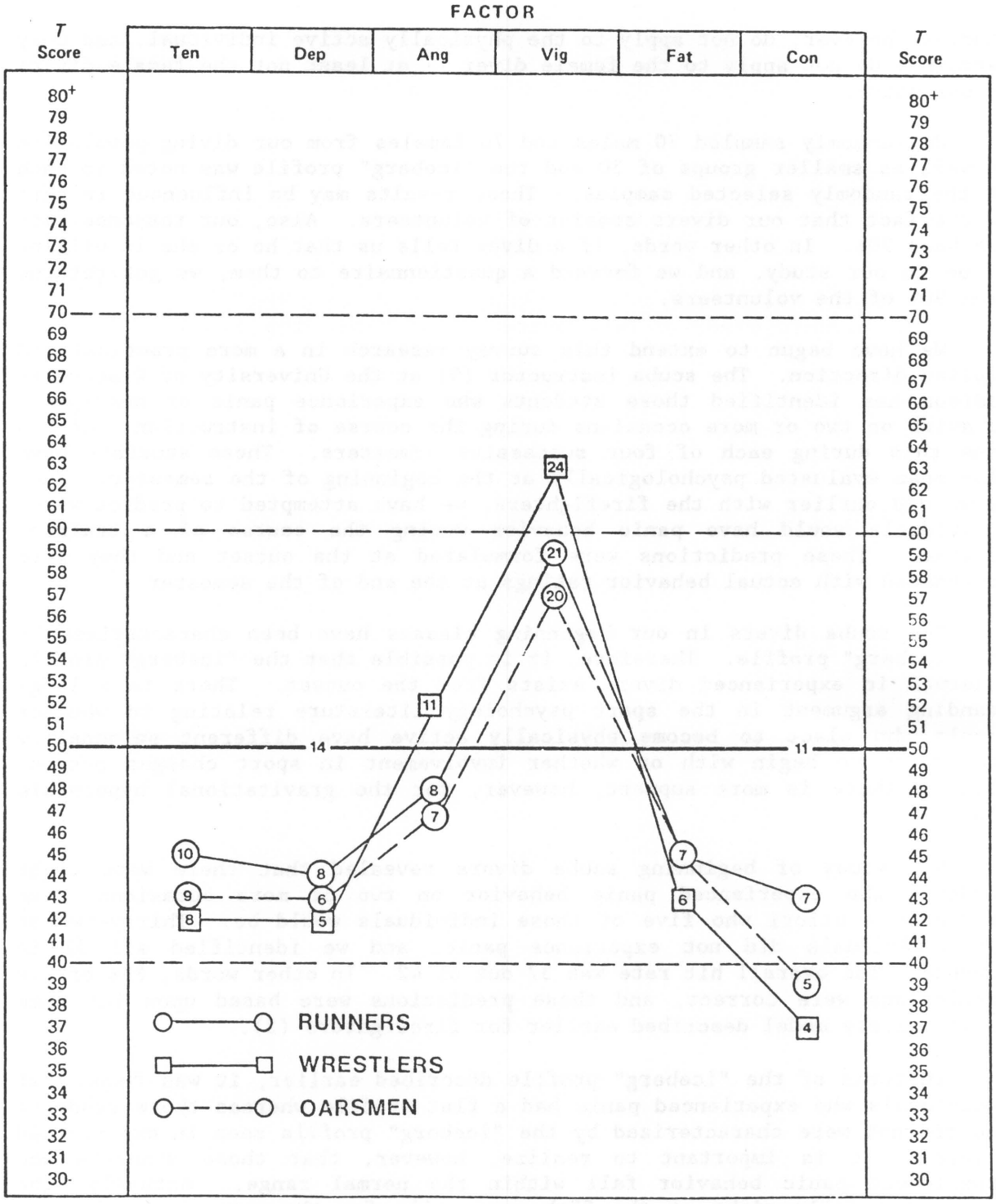

Fig. 1. The "iceberg" profile previously noted for athletes in distance running, rowing and wrestling (Ten = Tension; Dep = Depression; Ang = Anger; Vig k = Vigor; Fat = Fatigue; Con = Confusion). The population average falls at a T-score of 50.

studies, however, do not apply to the physically active individual, and they certainly do not apply to the female diver -- at least not the female divers in our study.

We randomly sampled 70 males and 70 females from our diving population as well as smaller groups of 30 and the "iceberg" profile was noted in each of the randomly selected samples. These results may be influenced in part by the fact that our divers consist of volunteers. Also, our response rate has been 90%. In other words, if a diver tells us that he or she is willing to be in our study, and we forward a questionnaire to them, we get returns from 90% of the volunteers.

We have begun to extend this survey research in a more practical and applied direction. The scuba instructor (9) at the University of Wisconsin-Madison has identified those students who experience panic or near-panic behavior on two or more occasions during the course of instruction. He has done this during each of four successive semesters. These students have also been evaluated psychologically at the beginning of the semester. Just as we did earlier with the firefighters, we have attempted to predict which individuals would have panic behavior during the course of a training program. These predictions were formulated at the outset and they were contrasted with actual behavior ratings at the end of the semester.

The scuba divers in our beginning classes have been characterized by the "iceberg" profile. Therefore, it is possible that the "iceberg" profile observed in experienced divers exists from the outset. There is a long-standing argument in the sport psychology literature relating to whether people who elect to become physically active have different personality structures to begin with or whether involvement in sport changes personality. There is more support, however, for the gravitational hypothesis (10).

Our study of beginning scuba divers revealed that there were eight students who experienced panic behavior on two or more occasions. We predicted a priori who five of those individuals would be. Thirty-two of the individuals did not experience panic, and we identified all 32 in advance. The overall hit rate was 37 out of 42. In other words, 88% of our predictions were correct, and these predictions were based upon the same *trait anxiety* model described earlier for firefighters (2).

In terms of the "iceberg" profile described earlier, it was found that individuals who experienced panic had a flat profile whereas those students who did not were characterized by the "iceberg" profile seen in experienced divers. It is important to realize, however, that those students who experienced panic behavior fall within the normal range. Actually, the group mean falls right at the 50th percentile for the general population. Again, however, these individuals do not have the "iceberg" profile characteristic of experienced divers.

These results explain in part why some workers in the field argue that research of this nature will not yield positive results because it does not include abnormal people. The assumption made by proponents of this view

seems to be that if a person isn't hospitalized for psychiatric reasons, they should be normal. Of course, that is simply not true, and in all of our studies we have found pathology of clinical significance in 10 to 15% of the subjects tested.

The research I have summarized in my talk today suggests that most of the problems experienced by the diver, and of course the firefighter in our earlier work, involve a complex psychobiological issue. While I have focused primarily on psychological issues, it is clear that one's psychological structure influences his/her physiological responses (e.g., ventilation). Furthermore, it is also clear that a feedback loop exists in which psychological or physiological stimuli can influence one another in a reciprocal manner.

I would like to conclude with the comment that the female divers we have studied have been psychologically more like male divers than unalike. Second, these women divers have been characterized by positive mental health. Three, these women divers possess the "iceberg" profile of elite athletes and active individuals that we have studied in other sports. While these findings make sense at a theoretical level, it is noteworthy that many authors have reported the converse. An effort has been made in my talk to focus on research evidence rather than speculation about gender differences in divers. We are presently doing more work on the panic narratives, and it is possible that we may eventually observe some gender differences. I would like to stop at this point in order to leave ample time for questions and discussion, and I thank you for you attention.

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DISCUSSION FOLLOWING PRESENTATION BY DR. MORGAN

FIFE: Could I start the questioning? I think you mentioned, perhaps related to the Cousteau work, that by psychological conditioning, you could extend the life of the tank. Did I understand you to say that?

MORGAN: Yes.

FIFE: The question I was wondering is, does this actually result in CO_2 retention?

MORGAN: We don't know. Dr. Lanphier, of course, could handle that question better than I. In my work with Peter Raven, Steve Horvath, and Barbara Drinkwater (11), and my later work with Koichi Hiroto, Bruno Balke, and Gary Weitz (12) we told people who were exercising at 100 w on the bicycle ergometer, under hypnosis, that they were going up a hill, down a hill, or sitting in an easy chair. We were able to alter their metabolic and ventilatory responses. We were also able to modify cardiac frequency, and when we told the subjects they were going up a hill their heart rate increased 15 beats per min on the average. Therefore, the change in perception of effort is not simply a "head" factor. There are physiological mechanisms involved as well. The specific mechanisms had not been iden-

tified, but I think the catecholamine response is certainly playing a prominent role. Oxygen consumption can be increased and decreased systematically. There is an older Russian literature involving subjects who were lifting dumbbells to the beat of a metronome, and when they were told that they were lifting heavier dumbbells their oxygen consumption increased (13). When they were told that they were lifting lighter dumbbells, their oxygen consumption decreased. In other words, oxygen utilization is governed in part by perception.

One of the things that we are going to be doing in our subsequent tank work at the University of Wisconsin is to attempt to see not only how fast a diver carries out an assigned task, but the efficiency of the act as well (i.e., use of air supply). They will receive a stimulus, and at the observation window they will need to push off and carry out the task. When they move off, we will record reaction time, movement time, time for completion of task (e.g., closing a valve), and the length of time required to return to the rendezvous point. An important dependent variable will be how much air was required to carry out the job. In other words we will be looking at the speed of performance, the accuracy of performance, and the energy cost or efficiency of the individual.

The psychologist who worked with Cousteau told me that they could teach people to be more efficient. Anyone who works in this area knows that some people use up their air supply faster than do others. Of course, if someone has a body surface area that is much greater than another person, this difference is easily explained. I am referring, however, to people with similar body sizes who use different amounts of air for the same task and time frame. The psychologist I mentioned earlier claimed that they could actually increase the length of time a given tank would last with psychological procedures such as meditation and relaxation training.

I have no reason to doubt that such an effect could be produced. Whether or not this would result in CO_2 retention, is another matter.

LANPHIER: I don't either.

FIFE: You would think if the oxygen consumption went down, the CO_2 production would go down also. So it might not do that. But that leads to the second question, and that is, we have always in the past thought that the reason women appeared to have their tanks last longer was because they had really less body size and, therefore, less requirement for oxygen. Would you hazard a guess as to whether women, because of the psychologic aspects built into the female, really are better equipped to dive than men? Is there any work that indicates that their oxygen consumption is lower given the same body size as a man?

MORGAN: If you consider men and women on the treadmill or on the bicycle ergometer, I do not believe so. However, when you consider exercise in the water, I think the differences in body fat usually observed in males and females can play an important role. Whether women are more efficient when working underwater at a constant work load of 50 w, for example, is another

matter. I have no idea if there would be a difference in oxygen consumption. Perhaps Dr. Lanphier would comment on this issue.

LANPHIER: I don't either.

HONG: I may shed a light on that. I touched on that in my presentation. When you compare the male and female divers in cold water, for example, not so cold, but a little cold, then you see the metabolic responses.

MORGAN: What temperature do you mean?

HONG: Say about 22 degrees C or so -- slight shivering. Female divers simply allow their body temperature to go down without invoking shivering. In contrast, in male divers, the first reaction is to increase the metabolism. So there is a difference.

There are other sexual differences. The women divers are smarter in this respect because they don't waste any oxygen. That could be one reason. Different thermal response.

MORGAN: Your theoretical rationale seems sound to me.

MAGALETTA: For years I have noticed a marked variation in my air consumption without any change in physical, mental, or emotional condition. Finally it dawned on me, the times when I use up to 50% less air are times when I am doing something absorbing underwater, such as photography, archaeology, or digging. I was wondering if this was skip breathing and again retaining CO_2 and it finally dawned on me what it was. I don't think so. I felt as good either way, for whatever that may mean. But when I am just swimming around with nothing to do, I burn more air than I do otherwise.

MORGAN: We have done a lot of work on what we call association and dissociation in endurance exercise. If we have people dissociate and take "their mind off of what they are doing", and we can do this using a number of different strategies, we observe an increase in performance of about 30% on the average. In other words, the subject can go longer at a fixed workload. However, we have not seen metabolic differences in these studies. I suspect that your anecdote relates to the fact that you were probably more relaxed in those situations or preoccupied with the activity you were doing, when you used 50% less air.

I would like to come back though to Bill's question on the men and women for just a moment. I think that it is fair to say that 98% of our divers buddy dive. There are a few who say that they would never, never, dive with anyone! That view is kind of interesting, and individuals who report that they would never dive with anyone also indicate in every case that they have experienced problems with dive partners. Again, however, about 98% of them buddy dive. Many men and women dive together as you are well aware, and it is not uncommon for the partner to be of the opposite sex. Therefore, if a man and woman are diving together, and the man's body surface area is greater, you would expect the female to have more air in her

tank when the decision is made to surface. This could be due simply to differences in body surface area. That could be one way of explaining the observed differences.

HONG: Surface area to mass at issue is higher.

BANGASSER: But oxygen use from a fixed volume tank would be less.

MORGAN: That would be one way of explaining our results. Of course, one of the problems with the surveys and descriptive work of this nature is that you are simply describing what people tell you. On the other hand, subjects with high lie scores have been eliminated from our sample. The question of why these differences exist remains in my view, and I believe we need more controlled laboratory study on this problem.

WACHHOLZ: Are there any moves or plans to survey these people again down the road, find out if they are still diving, see if their profiles have changed or to study non-basic students?

WACHHOLZ: But that was not with basic students.

MORGAN: That is right, there were a few, but most of them were experienced. We now have a database with approximately 5000 active individuals in it and we have recently completed three 20-yr follow-up studies of athletes in 12 different sports. Unfortunately, scuba divers were not available when this earlier work was initiated. In our 20-yr longitudinal study we have 800 athletes who were at the University of Wisconsin in the early sixties. We have psychological data on them from the first week of school and we are looking at them in 20-yr follow-ups. I am not really sure how long you need in order for a follow-up to be meaningful. If you are looking at the development of disease, for example, then you certainly need at least three or four decades between the pre-test and the follow-up if your subjects are young at the pre-test.

We, of course, will retain our scuba data, and we will preserve the data file. This will permit us to go back and follow-up on this at a later date. That is not one of our major concerns at this time, however, Our major concern now is moving into the Biotron facility with Dr. Lanphier in order to carry out research in the immersion facility. We are doing dry-land analogues of this right now in a sound-controlled chamber with tight controls. We plan to move from this artificial, rather sterile environment, into the underwater immersion facility in the University of Wisconsin Biotron. This testing will not involve a "real world" situation either. We will proceed into our diving tank the following year, and this will permit unencumbered movement. Finally, in the subsequent year we will move into the open water environment (e.g., lake diving).

In other words, we are going from the survey, or the epidemiology phase of the project; to the sterile environment of the dry-land analog; then into the immersion facility; followed by the tank research; and finally the open water. As we move along we have a series of studies that we have planned.

Of course, as we go along, questions keep coming up that we had not anticipated.

D'Aoust is in hyperbaric physiology at the University of Washington and he made the point in *Science* "that few reputable scientist would prepare experiments whose outcome they knew." (14). But the problem is that when you are trying to get funds, you need to convince people that you know what you are doing, and this often means that you must spell out what you are going to find before you start the work. As we proceed with our work, we are describing what we are going to do next, but in all likelihood we will probably end up going in different directions based upon what we find. As a matter of fact, in one of the proposals we submitted to NIH, the summary statement contained the comment that the first 2 years were well designed, but the actual work to be carried out in the third year was too vague. We didn't want to specify what we were going to do in the third year because that was going to be based on what we found in the first 2 years. I am sure that will apply with our divers as well, and therefore, the protocol I have described may change.

NUNNELEY: Do you have the feeling that the psychological profile and the tendency toward panic response, whether any of this is mutable? Can you train people? My interest is more in the direction of firefighters and other workers who have to wear masks. These people aren't in any manner selected.

MORGAN: The troops, what are you doing with them exactly?

NUNNELEY: They have to wear chemical defense gear, and enclosed mask.

MORGAN: MOPP gear?

NUNNELEY: We don't call it that in the Air Force.

MORGAN: I believe I know what you mean. I have done some work with the Armor Division at Fort Knox, and the soldiers are required to wear protective clothing in tanks for example. They have all sorts of problems in the sense that they have the necessary protective gear, but they can't get soldiers to sustain an effort at times because of the distress produced by the very protective gear upon which their survival is based.

NUNNELEY: Right.

MORGAN: I think that one problem with many military applications is that everyone is expected to be able to do the same thing. In point of fact, all of our research would argue in favor of selecting individuals who are not going to have trouble and use them. I, of course, realize the problems with such an approach in many industrial and military situations. If everyone must be able to do it, then the next step is to develop very rigorous training programs. In the diving area, Griffith, who was at the University of Maryland for a number of years, and Heyman at the University of Wyoming, worked on this problem and they have attempted to teach people to cope with stress underwater.

In a personal communication I asked Griffith to comment on a statistical aberration in his data relating to the divers who received relaxation training (15). He replied that the divers in the relaxation group either "loved it" or they "hated it." As a consequence the relaxation group was extremely variable -- more so than any of the other groups including the controls.

I think that you still are going to end up with a certain group of people that need to be removed from high risk situations because of their physical capacity and personality structure. Then there are a lot of problems with --

NUNNELEY: They take off their mask at the wrong time. They remove themselves.

MORGAN: That's right. You see, in the simulations that are done you cannot truly stress people. No IRB (Institutional Review Board) would permit you to stress them at the level that they need to be stressed at in order to really find out if they are going to "choke" or not. So a typical scenario is that you have firefighters wearing SCBA in a smoking room, for example, but they know when they go in the room that the floor isn't going to fall out from under them, and they know the wall is not going to come down on them. They know that they are going to come out when it is all over. So they pass the "stress" test which in point of fact, is not truly stressful.

Once these individuals enter a burning building, and their partner goes down beside them, or one falls six stories through the burning floor or the wall comes down, then they may rip their mask off. The incident at Three Mile Island, involved an operator who was in a stressful situation, and he had a hyperventilatory response as he approached the valve. He has reported this incident in detail, and he has described exactly what happened. As he used up his tank he heard the egress bell ring meaning that he had a maximum of two minutes to exit, but his entrance time far exceeded that limit. There was no possibility that he would get out of there unless he removed his mask when the air supply was exhausted.

Hyperventilators are obviously at much greater risk than are individuals who do not have such a history. I think people who have these profiles should either be screened out or taught to cope. There are significant legal and political implications associated with screening programs, but I believe these can be resolved.

Incidentally, I look in the classified section every day for "new" scuba gear, and I am always curious about why people say "hardly ever used, never used, or used once." I think a lot of people select themselves out of scuba diving. They get into diving, find out that it is not what they expected, and then quit diving.

KEY: I have a question with regard to panic when you said men panic less but they perceive whether something is life threatening or not. Was that only their perception? Were the women's perceptions less life threatening?

MORGAN: I think there are two point here. First, the men do significantly more cave diving, wreck diving, and ice diving. An example of one narrative would be this. Two divers were on a ship in Lake Michigan for instance, and they proceeded deeper and deeper. This happens to be a wreck near Sturgeon Bay that is very popular, and divers use it all the time. The diver in front kicked up silt, and then all of a sudden neither one could see anything. Of course, they could relax, take it easy, and just start feeling around, and they would eventually find the entrance. They did not have a rope or any form of safety line. The individual who described the incident panicked, and it happened to be a male diver.

KEY: And he considered that life threatening?

MORGAN: Yes, because he was running out of air, and he did not know how he was going to get out the there.

Another diver went into a tunnel on a cave dive in Florida. When he turned around to look for his partner, all he could see were the fins moving off into the distance. His partner was familiar with the cave but he was gone. They did not have a safety line, but he thought he knew how to get out. He started looking around, and then he sat down. He has written this up in the form of an article and his narrative was about five pages, single spaced. He sat down and said to himself, "here I am, I am a diving instructor, and they are going to find me down here dead! I've always told my students that they should never do this. My whole reputation is gone." As he continued to think about this he spotted light up ahead. He went up and found the chimney and went completely to the end of the chimney, but it finally came to a dead end. So then he returned to the cave floor and thought: "Did I pay my insurance premium?" Fortunately this is one narrative that you can laugh about. He estimated that he was down to about 4 minutes of air. The sun was in and out as the clouds moved around, and the sun broke through once more. He saw another opening, and his first thought was that it was probably another dead end. He decided to try it, but he also did not want to use all of his air. Then he decided that he might as well try because he was going to die anyway. He tried that opening, and it turned out to be the actual entry.

NUNNELEY: What did he do to his partner?

MORGAN: He didn't report all of that. His partner developed a problem with his regulator and he decided that he had to ascend. The other diver was too far in front of him. It was a bad situation. Those things happen.

WACHHOLZ: Has anyone considered producing panic in previously unpanicked people for training purposes to get over this sort of thing?

MORGAN: I don't think that ethically we can do that today, but it was done in the older literature. There is an older paper for instance, where the subjects received either a saline infusion or a drug that paralyzed the respiratory muscles. Within a very short period of time after receiving the drug, the subjects experienced respiratory distress. As you sit here now, you are all breathing comfortably, and you do not think about your breathing

until we call you attention to it. When you become aware of your breathing, you begin responding to this awareness, but this does not produce a panic state. In the experiment I mentioned earlier, however, the subjects experienced panic attacks when their breathing was arrested.

I really do not think you can justify experiments of that type. There is also Russian research involving the study of patients who were being supported on an iron lung. When the iron lungs were shut down, the patients became dyspneic even though there was no input from the respiratory muscles. In other words, individuals can develop dyspnea even though there are no cues provided by the respiratory muscles.

BANGASSER: I have two things. One is, if more males do the cave diving, wreck diving, ice diving, is there any correlation that they might be greater risk takers than females, or is there any way to look at that?

MORGAN: At the beginning we didn't know if there would be differences. Now that we have observed the differences, and remember that these are the only two areas in terms of diving behavior where we have seen differences, we need to explore this further. Since we did not see lower post-dive air supplies in the males, this would argue against greater risk taking.

BANGASSER: Another thing, a technique used by some instructors to raise stress among students is a buddy breathing exercise, only what you do is you tell the class that you are going to have a relay race under water. So you have half the buddy team descend and they start swimming about four lengths of the pool as fast as they can. Then they tag their buddy who is supposed to then swim for him in the relay race. However, you tell the people on the surface when your buddy tags you, you are not really going to race, you are going to tell them you are out of air.

Most of the time even with instructor groups, no one can do this. By the time the buddy gets back and they have to buddy breathe, they start buddy breathing and they come to the surface gasping because they can't take the stress of having raced and then buddy breathed.

NUNNELEY: Well, they have an oxygen debt.

BANGASSER: So that is a way to handle stress without saline infusions. It is pretty frightening when you realize if you are really out of air and need air how difficult it is to handle a buddy breathing skill.

MORGAN: I think in the beginning diver there are enough things that go on in the routine teaching of the course that those who are going to have panic will be detected quickly. The problem I have discussed, however, involves experienced divers who have been diving for a long time. What do they do when truly "stressed"? I guess my position is that it might be difficult to ever bring about an ethically defensible form of stress that you can really hit them with.

So what we are doing is this: We have stepped back and we are working at a theoretical level. Everything we know about the personality structure

of anxiety neurotics for example, reveals that if they are stressed with say an epinephrine infusion, exercise, cold or heat, they respond differently than do normals. Therefore, you would expect on a theoretical basis, that a diver would be at greater risk if he or she had that type of profile.

BANGASSER: One thing I wanted to comment about. That one exercise, when it was done at an instructor course, none of the instructor candidates were successfully able to carry it off. Later on they all realized, gee, I had an octopus regulator. I should have used that. They all went immediately to buddy breathing.

WACHHOLZ: Just a couple of things. A lot of people in diving instruction I think would argue that a lot of these panic situations are a result of lack of training rather than people who are just going to panic, particularly the cave diving people. I am not defending cave diving because I wouldn't do it. But they would point out that almost none of the cave diving accidents were from people who had been through their course training which is very extensive and very professionally done.

Another thing is, in listening to a lot of sea stories and looking at case reports of people who have panicked and survived, including myself, the fear of embarrassment or of being found having done a stupid thing, stops panic. People then resort to more rational behavior.

MORGAN: I think you are absolutely right unless that person is an anxiety neurotic, and then they might not be able to control their behavior. As we look through our narratives, we run across the type of thing you are talking about all the time. Someone experiences vertigo or hyperventilation, and they do the very things you just described. They might say, for example, I am going to get over on the wall and hold on to the wall until I get my act together (i.e., stop hyperventilating). So they just swim over to the wall and try to slow their breathing down and relax. Perhaps they can't at first, but then they eventually do, and they are able to come back and report it.

But I don't think that is the case for the true anxiety neurotic. What we are talking about is a small sector of the population, and those people are at risk when they are placed in stressful environments.

Let me just give you one other example of where panic has occurred in seasoned divers, and it involves two issues. One is getting caught unexpectedly in a kelp bed where you are all tied up, or in a discarded fishnet. Suppose there is some turbulence, and you are suddenly all wrapped up in an old net. You might start looking around and then realize that you can't get out of this trap. In every case where that has been reported to us, the diver was packing a knife and was able to cut free. If the diver had not had a knife, he or she would not have survived. In the diver's own view, he or she would not have been able to escape.

Now in the case of the anxiety neurotic though, my feeling is that the diver might forget that he or she even had a knife. He or she might develop

a doomsday kind of commiseration about the whole thing and not think straight.

WACHHOLZ: Another thing that is related I think to the event of panic going full blown is fitness. There are many more people getting into the sport from a wide variety, a wide spectrum of physical fitness and pre-existing health problems than there were a few years ago. I get people calling us up and saying, well, there is this person, he has had chest pain in the past or they are an older person, they are not physically fit or they have had some health problems, they are diabetic or something, not even that clear cut. The physicians and instructors fail to realize that there are events that you are describing that can happen where all of a sudden, bang. Diving is not the easy relaxing sport that it was only a moment ago before you were stressed, caught in a current, or swept downstream. Now you have to work extra hard. If you are not in good shape, you are going to be stressed much faster and panic will result much more quickly.

MORGAN: Let's say you are in good shape and that happens to you. You are at 50% of your maximum when that occurs. If I am in poor condition and it happens to me, I might be at 90% of maximum. We are both doing the same work, but you are at 50% and I am at 90% of maximum. Yes, there is a real good physiological basis for the panic in that case.

BANGASSER: It would also appear to me that your perceived level of your fitness would be relevant too. If you perceive that you are not fit enough to do something, whether or not you are, it would decrease your performance.

MORGAN: I have to respond to that one. In our 20-year study of former athletes and non-athletes from the University of Wisconsin, the former athletes are no more active than the former non-athletes in terms of their activity profile. However, their evaluation of physical self or estimation of physical ability is significantly greater than the former non-athletes. I think they base their judgment or perception on their former selves, not on their contemporary self. So there is a potential problem involving self-perception.

NUNNELEY: They think they are heart attack proof, too, because they are fit.

MORGAN: I think that is a very significant problem. I am agreeing with you. I am also saying that the perception can be inaccurate.

GREENBAUM: Bill, I am questioning your insurance company data separating male and female, those people seeking psychiatric help or counseling. Did they attempt to distinguish between the working and non-working fraction of the population when they collected those data?

MORGAN: No. And those results are from '82 as I recall. That is the most recent I have seen. Of course, I know what you are getting at. I think the issue of vocations and so forth becomes very, very important. But if you look at all these major epidemiological studies, the findings are consistent. The women divers in our study consist of commercial divers, women who

dive for a living, and we have recreational divers who are homemakers. There are also women who are actively employed and scuba dive for recreation. So we have a lot of different types of women divers in our study.

We haven't even thought about going back and fractionating occupation out. I don't think, for example, that we have enough commercial divers to really begin talking about whether or not commercial divers are different from recreational divers. We could at some point get to that level, but not yet.

DECOMPRESSION SICKNESS IN WOMEN

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DECOMPRESSION SICKNESS

Decompression sickness, or the bends, is a diving malady that although it has been intensively investigated, still poses many unanswered questions. Bends is a condition that results when gas, particularly nitrogen, is released from the tissues of the body. During a scuba dive, there is increased ambient pressure, which causes an uptake of nitrogen into various body tissues. During ascent these tissues release the nitrogen into the blood which carries the excess gas to the lungs for elimination during respiration. However, if the ascent is so rapid that the gas from the tissues cannot enter the blood as dissolved gas fast enough, bubbles of nitrogen may form.

Symptoms of the bends range in severity and include skin itch (skin bends), fatigue, limb pain (usually in the joints of arms for scuba divers (1), chokes, and central nervous system symptoms of numbness, altered reflexes, or paralysis. Neurological symptoms usually occur within the first hour from completion of the dive. Joint pain symptoms can occur later, usually by 12 hours within completion of the dive, but can be seen 24 or more hours later (2).

Decompression sickness is treated in a recompression chamber, which reduces the bubble size and allows a slow decompression to "surface" pressure of one atmosphere.

PHYSIOLOGICAL MECHANISM OF DECOMPRESSION SICKNESS

During a scuba dive, the air breathed by a diver has increased to ambient pressure of the depth achieved. As a result, increased gas absorption occurs into the blood stream. As the gas (oxygen and nitrogen, and some carbon dioxide) is carried throughout the body, the pressure gradient across the blood tissue barrier forces the uptake of nitrogen into tissues. Nitrogen solubility in tissues varies, so the amount of nitrogen uptake depends on the solubility of nitrogen in that particular tissue. For example, fat will absorb 5.3 times as much nitrogen as water, so it has high affinity for N_2. During a short dive, the watery tissues will increase in nitrogen. Conversely, during a prolonged dive, the tissues with higher saturation ability, such as fat, will absorb more nitrogen. Besides adipose tissue, the body has high fat content in the bone marrow, and the spinal cord, particularly the lower thoracic, upper lumbar, and lower cervical areas (1).

Another factor influencing the mechanism of decompression sickness is blood supply and circulation. A part of the body with good blood flow will saturate with nitrogen faster, and will also eliminate the gas more easily.

During decompression, N_2 is eliminated from the tissues into the circulatory system, as the surrounding pressure decreases. The excess N_2

passes from the veins into the lungs. Gas bubbles will form if the blood cannot carry all the nitrogen in a dissolved state, such as during rapid decompression. Both fat tissues and areas with poor circulation take longer to lose their supply of N_2.

The formation of gas bubbles depends on the total amount of dissolved gas. Since oxygen is used by the body, nitrogen, which comprises most of the divers air supply, and in addition, CO_2 are implicated. In the beginning stages of bubble formation, CO_2 may enter the bubbles. Since nitrogen is in greater supply, it is the N_2 gas that is more significant in the bubbles. However, CO_2 may increase the tendency for bubble formation in the diver.

It is this formation of bubbles that causes symptoms of decompression sickness. The mechanism of injury by the bubbles is not fully known and apparently involves several intravascular mechanical effects. Some of the body's responses to bubbles result in platelets and red blood cells clumping (which impedes circulation in small blood vessels (3), proteins are denatured (4), plasma loss can occur (5), and substances affecting the smooth muscles can be released (4).

SUSCEPTIBILITY TO DECOMPRESSION SICKNESS

Scuba divers prevent decompression sickness by adhering to the U.S. Navy Dive Tables, keeping accurate records of depths and times, and by allowing for a margin of safety. This margin of safety can be to stay less time at a particular depth than indicated, or to use the dive time for the next greater depth for a dive. Even when following the tables correctly, one member of a buddy team may develop decompression sickness, while the other member remains symptom free.

There are several factors that can increase a diver's susceptibility to decompression sickness. Obesity provides a large supply of fat which can hold more nitrogen. Impaired circulation can result in slow off-gassing of accumulated nitrogen. There may be several causes for impaired circulation, such as injury to an area, or vascular problems, such as atherosclerosis. Because of this, older divers may be more prone to the bends. Even vascular problems such as migraine headaches and varicose veins have been suggested as possible sources for bubble formation. Other factors implicated in decompression sickness are fatigue, dehydration, recent illness, alcohol either before or after a dive, smoking, a recent episode of the bends, and generally poor physical condition.

DECOMPRESSION SICKNESS AND WOMEN

Studies on increased susceptibility of individuals to decompression sickness led some investigators to question the general susceptibility of women to the bends. Since the U.S. Navy Dive Tables were developed with the male diver as a model, and studies and case histories of men were used in other investigations, the applicability of the dive tables to women was challenged.

In order to look into this question, a study of the records of altitude training at the USAF School of Aerospace Medicine was conducted by Dr. Bruce

Bassett. Although, incidences of altitude decompression sickness are not identical to those occurring to scuba divers, they are worthy of comparison. Dr. Bassett's initial study revealed a much higher incidence of altitude decompression sickness among the females in the Air Force Flight Nurse program, than in men undergoing similar altitude training (6). (See conclusion for later result).

M.A.W.D. SURVEY RESULTS

In order to investigate this further, a section of the Medical Aspects of Women Divers Survey (M.A.W.D.) conducted among divers by the author, dealt with incidence of decompression sickness (7). There were around seven hundred responses to this survey, with respondents coming from the sport diving community from the United States, the Caribbean, and several other countries. The women ranged in age from 16 to 63, with an average age of 29 yr. The women respondents had been diving between 4 mo and 17 yr, with 4.6 yr as the average.

The breakdown of the diving activity is as follows:

Dive once a week (minimum)	34.2%
Dive once a month	18.2%
Dive six times a year	19.2%
Dive seldom	2.1%
Dive on vacations only	20.0%

There was a variety of certification levels achieved by the women, and the breakdown follow:

Basic Scuba Diver	39.5%
Sport Diver (Open Water Certification)	14.4%
Advanced Diver	19.5%
Divemaster	1.6%
Assistant Instructor	8.2%
Instructor	16.7%

This survey attempted to answer these questions: Are women more susceptible to decompression sickness than their male colleagues? Are women more susceptible to decompression sickness during certain times -- during their menstrual period, or while using birth control pills? From the information given on number of years diving and diving activity, each person's estimated total number of dives was calculated. From the 649 divers used in this analysis, there were 88,028 estimated dives. Twenty-nine cases of decompression sickness were reported, giving a 0.033% incidence. Many cases of the bends were not treated, but if decompression sickness was suspected from the symptoms and the history of the dive(s), the case was listed as positive bends. Cases of skin rash were considered positive also, but not skin itch only. There were three cases of decompression sickness obtained while in hyperbaric chambers and one on a Tektite saturation dive, but these were not included in the evaluation of sport divers.

In order to compare this incidence rate in females to a rate in males, portions of the survey were sent in a newsletter that reaches instructors, assistant instructors and divemasters in Southern California. Then the data on women instructors, assistant instructors and divemasters (hereafter called the instructor group) were separated from the other women respondents. The women instructors made as estimated 44,154 dives, and 10 cases (three women were bent twice) of decompression sickness were reported. (Two other cases of decompression sickness in the male group made on mixed gas diving were not used in the analysis). The females had a 3.3 fold greater incidence of decompression sickness. This incidence in females compared to males is statistically significant by Chi^2 at the 0.025 level.

The female instructor group made abut half the estimated number of dives for the female respondents, yet had about a third of the cases of the bends (incidence of 0.023%). The incidence of decompression sickness among the female divers basic through advance (no instructors) is 0.043%. This difference in incidence is significant by Chi^2 at the 0.100 level. The data are summarized in Table 1.

TABLE 1

Incidence of Decompression Sickness

Group	Number of Dives	Number of Cases	Percentage of Incidence
All women	88,028	29	0.033
Women basic-advanced	43,874	19	0.043
Women Instructors	44,154	10	0.023
Male Instructors	43,126	3	0.007

In considering the reasons for possible increased susceptibility to decompression sickness for women, two areas of concern appear.

1. Birth control pills have been implicated in blood clotting and are speculated to cause a microsludging of the circulation. If the circulation is impaired, then susceptibility to bends increases. However, birth control pills used now are lower in dose than the earlier pills which initiated the concern.

2. The hormonal cycle in women, which results in the onset of the menstrual cycle, causes fluid shifts and possible vascular changes. Many women experience fluid retention 2 to 3 days prior to their period through the first days of the period. This swelling may increase the likelihood of the bends.

Both of these areas, diving while on birth control pills and during the menstrual period were questioned in the survey.

One section of the survey asked a series of questions answered by the women relating their diving histories while using birth control pills and/or while not using pills. Altogether, 63.5% of the women have made a decompression dive at one time in their diving history. For the male instructors, 70.2%, and for the female instructors, 60.7% have made decompression dives. Of the 179 women who made decompression dives while *not* taking birth control pills, 3.9% had decompression sickness. This and the following numbers were obtained by dividing the number of people who have had decompression sickness by the number of people who have made decompression dives. The numbers are not related to the diving activity since the number of dives under each condition is unknown. Another 2.2% of 454 women, while not on the pill, had decompression sickness on a *no*-decompression dive. Twenty-two and seven-tenths percent (22.7%) of the same group had nitrogen narcosis. The deepest depth achieved by women not on the pill averaged 115 ft, while the mean depth averaged 55 ft.

The same questions were answered by women who dived while using birth control pills. The incidence of decompression sickness was 3.7% for the 106 women who made decompression dives while on birth control pills. Another 1.3% of the 301 women while on the pill had decompression sickness on a *no*-decompression dive. Also, 43.8% of the women in this group have had nitrogen narcosis. The deepest depth achieved by women while using birth control averaged 112 ft, and the mean depth averaged 57 ft.

A similar set of questions were asked of the women about their diving activities during their menstrual period. Of the 131 women who made a decompression dive during their menstrual period, 3.9% had decompression sickness. An additional 1.2% have had the bends on a *no*-decompression dive. A summary of these data is in Table 2.

It appears that the percentage of women who have had decompression sickness on a decompression dive under the studied conditions (during menstrual period and on birth control pills) does not differ from the percentage achieved by women not on the pill. The cases of decompression sickness in the menstrual category are also accounted for in the "Pill" and "No Pill" groups. The percentage of women who have made *no*-decompression dives and subsequently were bent is slightly higher in the "No Pill" category, but this difference is not significant by Chi^2.

From the information on age, height, and weight, most of the women (80%) who have had decompression sickness appear to be normal or less than normal weight for their height. (This opinion is based on the following technique: 5 ft = 100 lb, add 5 lb for each additional inch + 10 lb). For

the surveys that included a question on age (one questionnaire was printed without questions on age, height or weight) the ages ranged from 21 to 52, with the median and average age of 31 yr. The ages of the women bent more

TABLE 2

Percentage of Women Who Have Had Decompression Sickness Under Various Conditions

Condition	Decompression Dives			*NO*-Decompression Dives		
	No. of Divers	Percent Divers	Percent Bent*	No. of Divers	Percent Divers	Percent Bent*
Menstruation	131	23.2	3.9	497	88.8	1.2
On the Pill	106	31.9	3.7	301	49.3	1.3
NOT on Pill	179	39.6	3.9	454	74.4	2.2

*If a diver was bent more than once, she was counted only once

than once ranged from 23 to 52 yr. The water temperature ranged from 40 to 80 degrees F for the women who had decompression sickness.

The information provided by the M.A.W.D. Survey indicates that women have a greater chance of having decompression sickness than males. Also, a diver with more training (the Instructor group) had less incidence of bends per dive than the group of women certified basic through advanced. A factor that enters the comparison of "instructor group" to "non-instructor group" is that for active instructors (that is,ones who are teaching, not just certified), possibly a higher percentage of their dives would be at depths less than 40 ft, since they would be student training dives. This factor could be, in turn, counterbalanced by these same active teaching divers pushing the tables, because of the necessity to make several dives a day either for training divers or for serving as guides. These numbers do not consider human errors in judgment. The percentage of divers having decompression sickness while diving during their period, on the pill, or not on the pill, appears to be almost equivalent.

CONCLUSIONS

About the same time the M.A.W.D. survey was evaluated, Dr. Bassett took another look at the record at the USAF School of Aerospace Medicine. The data were gathered on women exposed to high altitude at the U.S. Air Force's altitude chamber indoctrination program. This time a 10-yr period was studied (1968 through 1977). During this time 104 individuals were treated by recompression for altitude decompression sickness, and 32 (31%) were women (8). The incidence (number of cases/number of exposures) of bends in men was 0.09% and in women it was 0.36%. The fourfold greater incidence is statistically significant at $P < 0.005$.

Both the M.A.W.D. survey and the altitude decompression sickness study showed an increased susceptibility to decompression sickness in women. The M.A.W.D. survey resulted in a 3.3-fold increase and the altitude study found a 4 fold difference in incidence. Although these studies do not prove an increased susceptibility for decompression sickness in women, they certainly suggest the possibility.

The factors influencing the increased susceptibility can be speculated on to include the higher proportion of body fat, the fluid shifts and fluid retention related to the menstrual cycle, hormonal changes, and use of oral contraceptives. More subtle factors may be implicated upon further investigation. Dr. Bassett has questions on the prevalence in women of these possible factors: Perfusion anomalies related to an increased susceptibility to the bends; or hematological differences related to platelet aggregation triggered by bubbles; or vasoactive responses with increased release of substances caused by bubbles (8).

In order to keep this in perspective, please note that millions of dives have been successfully made by women divers following the U.S. Navy Dive Tables. The author, an avid diver, urges common sense in planning dives and recommends to stay less time than indicated by the tables. Also, record depth and bottom time accurately, and take a 3 min safety stop at 10 ft following deep no-compression dives. This information is not intended to discourage the woman diver but to promote safer dive planning.

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DISCUSSION FOLLOWING PRESENTATION BY DR. BANGASSER

MORROZ: On this survey, as in "Women in Fitness," I think physical fitness might have something to do with it, too, because men tend to get involved in sports more than women do. Maybe that's the only thing she does is just dive and that might have something to do with it, too.

BANGASSER: By taking the active instructors who are diving more regularly it might eliminate the less active group. In the total survey, the participants expressed a variety of diving experiences.

FIFE: Susan, may I ask you a question about the way you handled your statistics. When the same person got the bends twice, you showed them as two instances of bends.

BANGASSER: Right.

FIFE: Now it's conceivable that these people either are more susceptible, in the first place, as an individual characteristic or that they're doing something wrong twice the same way. What would your statistics have shown if you had simply counted them as one instance? If you eliminated the repeat instances they would drop from 0.023% to 0.016%. Incidentally, I would not have included skin itch or rash in your statistics. They certainly are bends, but many people don't think to report it without being conditioned to do so.

BANGASSER: I don't think dropping the repeaters might change it because it's a small number. But I'd have to go through the statistics and verify this.

NUNNELEY: I have some of the Air Force files here that you might be interested in. But I want to relate a little of the background. When I first came across this statistical idea and, of course, it has been carried to the point by NASA where they think that the women who are going to be on Extra Vehicular Activities (EVAs) have to denitrogenate longer than men. If they're going to go out in space they're going to get decompression. So they're really worried about it. And it all goes back to the original passive study. I was wading through this this morning and the first piece of paper the Air Force had was a report written by somebody named Wiggs in 1969. What he noticed, and a couple of these thing were new to me, was a sudden increased incidence to bends in the nurses the year preceding his report. He then gave several pages of description and speculation about it. He said symptoms were typically delayed 4 to 8 hours beyond the time they came back to ground level. He stated that, "Symptomatically, they resembled migraines usually with neurological symptoms or some of the cases resembled acute floating anxiety attacks." He also noted that some of them had an

unsatisfactory response to recompression treatment.

Now, my interpretation of that is that they may have been seeing something entirely different in the women than in the men. And the women had different physical standard as well (nurses vs. pilots). So that they may have included women with a history of migraine or other related things whereas the men with such problems were already excluded from the test population. At this point Wiggs wasn't comparing women to men. He was saying, "We've got a problem with the women now that we didn't have the previous year." But that really kind of runs up a flag to me because he's saying migraine and acute floating anxiety attacks, delayed and they didn't respond well to the treatment. Now, that makes me wonder if these women are just having a general stress response and they would have had the same thing if he had made them run two miles or sit in a hot chamber and that it wasn't altitude at all.

Now, Bassett's early study, was strictly retrospective and statistical. My doubt about its validity originated from talking to people who were there at the time the altitude exposures took place. They said there were relevant background factors that weren't written anywhere. And what they told me was as follows: The men were air crew members taking a refresher course with a certain altitude profile. The women were flight nurses getting their first exposure to altitude; the nurses had a different and somewhat more provocative altitude profile. The lecture materials they listened to and the emphasis by the instructors was quite different in the two groups. Thus, the medical standards and past experience were different for the two groups. If you're talking about bends, you're talking about reports of symptoms. In addition, motivation differed. The men probably had a more macho attitude, and if they reported decompression sickness that was the end of their flying career. To the women, it made no difference.

I have strong reservations about the initial Bassett study. The one he did later had fewer of these problems. But then I say to myself, "What if Bassett had never run up the flag? Nobody would have noticed a small difference." These are rare events, 3 cases versus 1 case out of 33,000 exposures, so chance plays an enormous role.

MAGALETTA: I've been told exactly the same thing as Dr. Nunneley just mentioned. And my question is almost the same, and it's actually for both of you. I'm trying to find out why women might have more decompression sickness than men before we even, in fact, know that they do, so aren't we in the position that you mentioned before where it's a negative approach to a non-question that's stifling us, keeping us from going anywhere?

INNES: I have one question, too. Was your survey done in '78, or 77?

BANGASSER: '77.

INNES: And is there any survey, even of the type that you did, being reconducted? I mean, if we're going to look at this question and decide whether women and men have different responses to decompression sickness, you've got a lot more women diving now than you did in '78. You've got a

whole different population. And I guess that's why we have this seminar, to stress that need. But it would be very interesting to do this again 10 years later, say in '88.

BANGASSER: It would be.

FIFE: I have been gradually changing my view on women's susceptibility to bends. For a long, long time I simply accepted that women probably had a greater susceptibility than did men. But then a couple of things have come out recently that have begun to make me think that there may be no real difference. One of them I mentioned earlier about the 30,000 dives the George Bass has been doing, almost all of which are decompression dives, and probably one-third to one-quarter of these divers are women, and the only three bands they've had were in men, not in women. That's one thing. Now, of course, he uses ultra-conservative diving. But still, with that ultra-conservative diving, men got it but the women didn't.

Recently, there was something that came out by Walligora and the other people at NASA looking at females in simulated EVA operations. What they found was a kind of interesting conflict. They looked with a Doppler at the circulating bubbles and recorded the instance of bends, which is simply limb bends, decompression sickness, a pain in the joints. They had, I believe in one study, 14 men and 14 women. They found out that 18% of the women on the same flight profile had circulating bubbles, but 9% had bends. 23% of men had bubbles, but only 6% had decompression sickness.

Now, this brings us to something that I just want to throw out on the table for us all to keep in mind. And it is that circulating bubbles is a different disease than limb bends, because limb bends are result of bubbles that are enlarged in the tissues and probably a particular type tissues such as joints, joint capsules and tendons, and it's the enlargement of these bubbles pressing against the nerves that may be causing the problem. Whereas, in circulating bubbles, these bubbles you don't feel until you begin to have enough trapped in the lungs so that you begin to get pulmonary hypertension.

The main problem is that the samples were small but the authors said the differences were not statistically significant.

I think I'm beginning to feel that perhaps there really isn't any difference between men and women, and that we could perhaps put this to bed and not worry about it. I've begun to feel that diving is about as safe for women as for men except in the case of pregnancy. Incidentally, we require all of the dives done under our University auspices, to take a 10-ft stop regardless of whether they need it or not.

McGEEHAN: How long?

FIFE: Well, if it's a short dive, we will agree to 3 minutes. Otherwise, it's 5 minutes.

BANGASSER: Regardless of the depths they're in?

FIFE: Yes.

MAGALETTA: And regardless of the number of dives?

FIFE: In addition to following the decompression tables they still have to take a 10-foot stop whether they need it or not. Now, if it's in the decompression tables, that they have to take a 10-foot stop, then we don't require another 10-foot stop.

MAGALETTA: If they make three dives a day, will they make that stop?

FIFE: Ten-foot stop every time.

MAGALETTA: Of course, the first two are increasing their total nitrogen level.

FIFE: Well, if you start looking at that, they really aren't because there's more tissue out-gassing than is in-gassing. And out-gassing occurs faster under pressure than it does on the surface. So you really probably are doing them a favor for a couple of reasons. One is that the bubbles still are smaller and the outward pressure of that bubble is indirectly related to the diameter of the bubble. The smaller the bubble, the greater the drive for out-gassing. For example, if a bubble is 1 cm in diameter, the pressure inside the bubble, greater than outside, is only about 0.03 mmHg. But if the bubble is at a tenth of a micron, it's around 7,000 mmHg. And the bubble disappears in a hurry.

So anyhow, I'm beginning to think that maybe you're not in as big a problem as you think. I don't know what that does to your statistics, your findings.

BANGASSER: At the time of the survey most divers were not taking safety stops.

KEY: Something I've done has worked out very well. If people are diving in 60 feet, add a couple of minutes to the bottom time and stop at 30 feet and take a blow, i.e., ventilate your helmet, rest, just hang there on the downline. And then come up and finish your regular stops.

WACHHOLZ: Did you say that you only require the men to have 10 foot stops?

FIFE: No. Everybody. It's a requirement of the University now. And furthermore, unless there's some reason for not doing it, we request, in all my diving and the diving of my people, to use the next greater depth and the next longer bottom time for their calculations. Just add in that additional safety.

HARRISON: A question. I tend to agree with what you say and I don't know whether there really is a question here. But how do you settle the question? You can't really put somebody to test their susceptibility as Susan said. Do you have any thoughts on how this question could be settled?

FIFE: Yes, I think I do. Bunny Key and I tried to get together and do this several years ago when we were going to repeat van der Aue's work where he had about 160 men and took them on bounce dives and looked at the time on bottom. He was able to see that a couple of minutes of bottom time made the difference in whether they got the bends or not. We were going to repeat the same profile with women. Now the problem you run into is first of all, I wouldn't do that with university students. Bunny was going to try to get enough commercial divers to be subjects because they go into this with their eyes open and you're less likely to have a legal problem.

But it still presents a legal problem when you intend to give the person the bends. So we simply have not found either the funds to do that or the people. Maybe the Air Force can.

NUNNELEY: I'm on the Human Use Committee and have been for years. And for the most part, now, the studies are based on bubbling, Doppler detection of bubbles. We are now doing experiments which elicit symptomatic bends. There are some serious questions about the relationship between bubbling and bends. Specifically, could subjects develop bends without first bubbling?

The Human Use Committee therefore approved giving people the bends. We've had a couple of studies like that including the one that was reported at the same meeting as the paper you just talked about. And in addition to Walligora's NASA paper there was also a related paper in which they thought they saw some bends in the women that were a little different from the men. But once again, if you will look into the details, the substance of the report was based on one woman. What they were most interested in was one woman who some hours after the exposure had some kind of nonspecific symptom, and they stuck her in the chamber and she felt better. But the whole thing was rather atypical. It just wasn't typical bends. And then you are in a quandary: Are women's bends different from men's, or are you treating something that wasn't really bends?

FIFE: Bunny, how many women commercial divers could you get in one place?

KEY: Probably a dozen.

FIFE: How many of you would be willing to accept the data based on experiments repeating van der Aue's work? His group of subjects was titrated and ended up with the bends at some point in time during this series. Would that be enough to even be able to be talked about? What do you think about it, Ed?

LANPHIER: I think it would be a little better than nothing.

BANGASSER: Those would be highly selected women. They're used to commercial diving. If they had a lot of trouble with decompression sickness they wouldn't be in the field.

FIFE: That may be true. On the other hand, if you look at their physical conditioning, and you are the expert on that, would you say they are in any better physical condition than active scuba divers at large?

BANGASSER: Commercial divers who dive constantly are probably generally in better condition than the sport diver.

KEY: I think they would be.

INNES: I think it would be by the nature of their work.

LANPHIER: Well, there are some studies of North Sea male divers which showed that they weren't in very great shape at all. As a matter of fact, I would hold a great deal more reservation of male commercial divers than I would of active sports divers. You know, you drag them off the shore and wring them out the first of the season. Right?

INNES: The other problem might be that commercial divers have had pain only bends or some type of bends that they didn't report. At some point, maybe they have a greater susceptibility in the future particularly if they were working for a corporation that boots you out once you report decompression sickness.

FIFE: In van der Aue's study they were all Navy divers and they had no reason to conceal that.

INNES: If the women have been in commercial diving for a long period of time, it's possible they've had mild bend cases and never reported them and don't want to report them. So then you have that factor to put in there as well.

WACHHOLZ: Well, there must have been a good deal more Air Force females that have been taking the altitude test since Bruce's work that could be looked at again with better control on the survey.

NUNNELEY: I'm not sure the controls would be any better. They have altered the profiles they used. What they've done is take out what they regard as the provocative parts of rapid decompression. It never seemed to be the big problem.

FIFE: Let me add another interesting side issue on this. And that is that the Air Force Cadets, who came down to take altitude orientation had about the same instance of decompression sickness as the nurses were having.

NUNNELEY: Yes. And they're mostly men.

FIFE: So the question is it may not be a sex difference. It may be due to stress or some other things. Does anybody else have any points to bring up?

McGEEHAN: Someone is doing a study like that. Why not apply to the memberships of the guiding Scuba agencies for volunteers? You know, your women instructors probably some of them, like myself, would love to have further research in this area. And you might get people who would volunteer to be subjects.

FIFE: Well, there are two things to consider. One is the funds because it would be a very expensive thing, and the other is the legal aspects. Maybe that's something we ought to put in our recommendations of things that need to be looked at because that would be quite definitive.

One final thing before we leave this subject, the only difference that I know of between diving in a chamber and diving in the water is this question of skin bends. In the water the partial pressure of nitrogen is only 600 mm of mercury no matter how deep you go. In a chamber, it depends on what pressure you're at. And so in a chamber you can get in-gassing through the skin. This apparently is the reason why skin bends in a chamber are far more prevalent than they are in the water, whatever that means. In fact, in passing, this phenomenon should also apply to dry suit diving.

LANPHIER: Well, temperature difference is one factor there.

FIFE: Yes, of course.

LANPHIER: One thing I'd like to bring out though is the fact that people who are volunteering for something can throw bias in there also.

FIFE: Yes. But as you point out, is it better than nothing?

WACHHOLZ: I'd like to ask you a question. Given what's been said here, I think Sally has talked about fluid changes and a lot of the things that we had been told and believed are theoretical reasons why someone is more susceptible, and now questioning the validity of these earlier surveys, how legally safe would it be for us to walk away from here and say, "There's no difference," given what's published?

INNES: I think the important thing from a legal perspective is to realize first of all that the Navy dive tables, I think, were made for people -- and we'll have to go back to the original research -- that is 18-year-old males. As a general rule, male or female, I think you ought to knock 5 to 10 minutes off the tables. And that's what I teach in my classes. I now am at the point where we're very much emphasizing safety stops, and have found them to be of great use. I do that male or female. The average male person that goes through my class doesn't qualify for Navy sea standards.

What I would say, rather than go away with the conclusion that women--that there is no difference, the way I would present it and the way I'm going to modify my lectures, because I've been presenting that women had a greater susceptibility when using birth control pills. I will say we used to think that. And now we believe that it may be this way. But further research needs to be done.

Again, I would stress for all sport divers, I think you need to knock 10 minutes off of the tables. And that goes for all sport divers. We have a very serious problem with the bends where I live with sport divers because we do a lot of spear fishing off the oil rigs in the Gulf of Mexico. It's a lot of deep, deep bounce diving. A lot of deep, repetitive dives to deep depths for short amounts of time where the tables don't work. You talk about the psychological influence of women, the psychology of the macho male

ego image goes hog wild out there. At the Jo-Ellen Smith chamber, there's a regular business in the summertime when sport divers are pulling in off the roads.

BANGASSER: Male or female?

INNES: Male. Much more often male.

BANGASSER: They are more susceptible.

MAGALETTA: Did I understand you to say that you think that the Navy diver has less reason to lie about bends than the other group?

FIFE: Not the Navy diver. These were people who were experimental subjects in van der Aue's study. They were young people who were conditioned to find out what point they got the bends. They all did get the bends. And they all intended to get the bends. It was just a question of where, in the profile, they got it. And they came so close together in terms of depth and time, that I suspect it was pretty close to being an honest observation.

DIVING AND SPORTS MEDICINE FOR WOMEN

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Amenorrhea, of all medical topics relating to sports medicine for women, is currently the most popular. There is hypothalamic and ovarian amenorrhea. Ovarian amenorrhea is divided into failure and polycystic. A simpler classification is just hypo-estrogenic and euestrogenic amenorrhea. Some of the more popular discussed etiologies of amenorrhea in the chronically exercising female are physical stress, psychic stress, percentage of body fat, total body weight above or below the ideal, body composition, amount and duration of exercise, natural body opiate production, increased prolactin production, hypothyroidism and carotenemia. Amenorrhea will be found in chronically diving women the same as in chronically exercising women. The occasional sport diver will no more be faced with the problem than will the occasional athlete who stays below a certain amount of exercise per week. Prior menstrual dysfunction and multiparity increase the probability of amenorrhea.

Any of the above may work synergistically, in that either physical, mental stress or pain can increase enkephalin production or prolactin. And if prolactin can be kept elevated long enough, amenorrhea can result. If weight loss and a decrease in body fat is added, the chances are greater. The amount of actual exercise experienced by any sport diver underwater should be negligible unless there was poor planning or an emergency occurred. For the professional female diver or one whose main interests or livelihood demands significant time under water, the exercise can be severe and/or chronic. Chronic hypothermia with or without its resultant weight loss is a stress, as well as the mental stress of the dive itself.

J.R. Willson when at Ann Arbor, Michigan, studied four women (two ovulating, two on birth control pills), all four well acclimated to compression chamber diving. He studied prolactin, dopamine, norepinephrine, epinephrine, cortisol, and progesterone. He found prolactin increased 4 to 10 times after each hyperbaric exposure, regardless of birth control pill usage. Dopamine, which inhibits prolactin release, tended to rise or be stable rather than fall as prolactin rose. Cortisol changes were inconsistent. A rise in norepinephrine was the most consistent catecholamine change. Prolactin response was inhibited by bromocriptine, a dopamine agonist. These women were at rest in the chamber but the results are the same as those seen in chronically exercising women.

Hyperprolactinemia has been associated with psychological stress. Bromocriptine has been shown to significantly improve depression, feelings of inadequacy, anxiety, hostility, and decrease libido in hyperprolactinemic women.

What is the relationship between prostaglandin, prolactin, and endorphin? Tissue trauma releases prostaglandin which in turn will release enkephalin or endorphin to help remove the discomfort of the prostaglandin.

B-Endorphin is a dopamine antagonist which when low will then allow prolactin to increase, but endorphin can as an endogenous opiate cause a rise in prolactin independent of dopamine levels. Psychic traumas with or without prostaglandin increase can also increase endorphin release and therefore an increase in prolactin. Pain and/or breast stimulation can cause endorphin increase and/or prolactin increase at least briefly with acute stress or stimulation. It seems, whenever physical or mental stress is successfully controlled or when the breast is stimulated endorphin and/or prolactin will be elevated either briefly or chronically depending on the stress. If the elevation is chronic enough amenorrhea can result.

Running and many chronic physical activities can cause joint, ligament, muscle discomfort, as well as produce breast bouncing in the female and occasionally in the male, and in either of male or female can cause nipple stimulation. Nipple stimulation can cause lactation in the male or female. Many are now using nipple stimulation to produce oxytocin release for stress testing the fetus in the last trimester of pregnancy rather than a pitocin drip. Even a routine breast exam can raise prolactin levels.

Frequently noted phenomena said to be associated with prolactin and/or endorphin release are the runners high, decreased appetite after exercise, decreased libido after exercise, and decreased awareness of injury after sport participation for 2 to 36 h later.

Prolactin levels are higher in women when running than when riding a bicycle where the upper trunk is relatively motionless. An experiment done with nine women compared prolactin levels during a run with a bra on and a bra off and a bicycle episode with a bra on. Although the bra off run results showed prolactin higher than the run with the bra on, it was not stastically significant. There was a marked difference between the run with the bra on and bicycling with the bra on. Breast motion is suggested as the cause of prolactin elevation, yet simple trauma can not be ruled out. It is unlikely that breast stimulation will be great underwater but equipment designers should keep it in mind.

Amenorrhea is 25% $\pm$ in female runners, and 12% $\pm$ in cyclists and swimmers. When cyclists and swimmers increased their training there is no resulting increase in amenorrhea. When the runners increase their training there is an increase in amenorrhea in proportion to the miles per week. Runners have less body fat. Neither cycling nor swimming compare with running in body trauma, i.e., knees, feet, hips, and breasts. Trauma on one hand, and breast stimulation on the other hand may increase prolactin, or enkephalin which may also increase prolactin.

The best predictor of a woman's menstrual pattern during training, according to Dr. Shangold, is her pretraining menstrual pattern. Thinness is associated with amenorrhea regardless of training.

Some frequently quoted body fat percentages are as follows: 17% of the body weight must be fat for menarche to occur and after age 16 at least 22% of body fat is needed to maintain menstrual cycles. These numbers are far from absolute. There is no completely accepted method of measuring body

fat. Competitive distance runners have the least amounts of body fat at 7% to 8%, recreational distance runners 15.2%, and mature non-athletic women 26% to 28%. Numbers vary between authors and methods of measurement.

On the basis of weight loss alone (only a portion of which represents body fat) it is said that a 10 to 15% loss of normal weight for height may result in amenorrhea. Another view is that women who weigh less than 115 lb and who lose more than 10 lb after the onset of a running program are most likely to develop menstrual dysfunction.

Therapy for amenorrhea in an athlete first must include an adequate work up to rule out dangerous or easily corrected pathology. For the hypoestrogenic amenorrhearic, estrogen has been recommended with the addition of a progestin to protect against endometrial carcinoma. Some feel bone loss can be significant and should be prevented before it starts. Atrophic vaginitis must be treated in any age group. Although some refuse estrogen therapy, others may welcome it. For the euestrogenic amenorrheaic or the oligomenorrheaic female athlete, there is not doubt in anyone's mind as to the benefit of cyclic progestational agents, to protect against endometrial hyperplasia and/or cancer.

Not everyone feels that the amenorrhea of the competitive athlete is necessarily a disadvantage. If a woman is prone to anemia, due to blood loss during menstruation and if the trauma of running results in cell damage and iron loss, amenorrhea may well be a protective mechanism.

Delayed menarche has been noted in young athletes such as dancers and swimmers who begin their intensive training prior to puberty. So far this has not been a problem with diving, in that most certifying agencies have a minimum age of 15. But as women become greater financial prospects for the equipment houses, with more comfort in gear resulting, the outfitting of children and equipment for children may be just around the corner. Whether this is good or bad remains to be seen but the same delayed menarche will occur depending on the amount and intensity of diving. If this is to be a problem for young girls, so also for young boys. Some feel the child athlete should be learning the mechanics and dexterity of sports rather than endurance and muscle building with strenuous exercise. Of course there are those who disagree.

Some say the testosterone necessary for muscle building is just not available to the prepubertal athlete so time is being wasted if actual damage is not occurring with heavy exercising before puberty.

Once the intensity or chronicity of the training decreases, most young female athletes have gone on to a normal menarche provided no chromosome abnormalities exist. It is interesting to note that the prepubital athlete tends to maintain a lower body weight throughout life even after training has stopped.

Testosterone has been associated with aggressive behavior. Whether aggression is necessary or desirable in sports is a concern to many. Testosterone is thought to increase synthesis and storage of glycogen in

muscle; which of course is very important for muscle energy. It is also thought that testosterone may increase the muscle to body weight ratio and may also be used for muscle fiber repair. Some studies have indicated a decrease in testosterone after maximal exertion, but this seems to be true mostly in the male rather than the female athlete. Other investigators have shown increased levels of testosterone after exercise in female athletes. We know that fat cells in women are a site of aromatization of androgens to estrogens providing and extra-gonadal source of estrogen. So women with decreased body fat may have low estrogens. Studies showing testosterone increased in women after exercising found the increase still within the normal range for females (just slightly higher than the non-competitive women).

Some have suggested the three-fold increase in norepinephrine and epinephrine with exercise may enhance testosterone secretion. Certainly the role of catechole estrogen such as 2 hydroxyestrone may be important, it will reduce prolactin. In studies of norepinephrine and epinephrine secretion in the pregnant athlete, increases in norepinephrine may exceed increases in epinephrine. When this is true, there are more uterine contractions.

Studies of follicular stimulating hormone (FSH) and luteinizing hormone (LH) during exercise show no particular pattern. Their response to luteinizing hormone-releasing hormone (LH-RH) at high altitudes, show a powerful and protracted stimulation irrespective of altitude or sex.

J.R. Willson, in a preliminary communication in which he studied two women, concluded there were no FSH, LH, estradiol, progesterone, testosterone or ovulation changes in chamber dives to 130 ft for 20 min, 7-8 times during a menstrual cycle. In one of the subjects the testosterone level was elevated above normal but she apparently was not ovulating. I am not certain what this study means, I think it just needs to be mentioned. It is too bad Dr. Willson did not have testosterone, FSH and LH studies in his first experiment with four women in chamber dives, and that he did not check prolactin levels in the second experiment.

Ralph Hale at the University of Hawaii studied LH, FSH and testosterone, cortisone and prolactin in marathon runners and the U.S. Women's Water Polo Team at the conclusion of a strenuous practice session. Prolactin levels were up in both groups and testosterone levels were up in marathon runners. One possible flaw is that the runners had true competition and the polo team just a workout session. Also Dr. Hale showed LH levels reduced in the runners, others have found elevations of LH.

The discussions were pertinent to our interests. As was stated, the prolactin increases and the endorphin elevations in any kind of stress produce many changes hormonally, in both male and female. Certainly this could be applied to diving, if the stress is intense and/or chronic enough.

Rat studies have shown a decrease in libido and fertility in male rats after chamber dives. Australian studies have shown a significant

increase in female offspring to male abalone divers and male pilots of high performance aircraft.

There is little information on the physiological response of women running at high altitudes, except at Mexico City during the Pan Am and Olympic games. The reduction of performance was the same for males and females. Early Air Force studies suggest women have an increased incidence of altitude decompression sickness and of maximal oxygen uptake over that predicted for men. Females tolerate the effects of altitude better than males as seen by a lower frequency and shorter duration of mountain sickness. Also at altitude, women experience fewer alterations in resting, heart rate, body weight, blood volume, ECG, and blood chemistry than men. Most respiratory studies are similar in men and women at altitude, except that women hyperventilate more than men, thereby increasing the partial pressure of oxygen and decreasing the partial pressure of carbon dioxide, which is felt to explain the better tolerance of the stress of altitude by women.

Differences in physical strength may be significant in some occupations and sports but underwater it seems to be negligible. Assuming comparable swimming skills, Bunny Key (a commercial diver) said it all when she noted, "without brains and equipment no one will move a 500 lb flange underwater regardless of bicep measurements."

With the older birth control pills high density liproproteins (HDL) were known to decrease and low density liproproteins (LDL) and cholesterol increase. Exercise is known to increase HDL and lower LDL and cholesterol. It is suggested that the HDL-cholesterol ratio of athletes on birth control pills is no worse than non-athletes not on birth control pills. Some studies of low dose birth control pills are showing no more lipid difference than in the non-athlete not on birth control pills. Because of thromboembolic problems, diving while taking birth control pills has been considered a hazard by some. The only animal studies were by Dr. William Fife, at Texas A&M who compressed sows with and without Zorane and noted no difference in the instance of decompression sickness (unpublished).

There has been no evidence that the anatomic problem of stress incontinence is made worse with exercise; yet it has been well noted that if an increase in exercise causes more frequent or more intense intra-abdominal pressure, symptoms will be more noticeable. Kegal exercises and surgery remain the main stay of therapy. Certainly women for centuries have been aware of the value of emptying their bladder before any physical exertion.

Women experience less evaporative heat losses than men exposed to the same thermal stress. Women usually have higher skin and body core temperatures at the onset of sweating. This has been quantified into 2° to 3°F higher temperatures in the female before sweating occurs. Also women have fewer sweat glands. These almost universally accepted statements have some negative and positive aspects, depending on the sport involved, but in light of Dr. Nunneley's information today, the above statements may need revision in the future. In the high thermal stress situation, high core temperatures could be a detriment to anyone, especially a pregnant female. (First

trimester may cause teratogenesis; later, premature labor). On the other hand, there will be less fluid loss from sweating in the female than in the male athletes. In the Montreal Marathon 1982, the higher than anticipated ambient temperatures created many heat problems. Yet the men (good athletes all) were affected more than the women. There were 50 cases of heat stroke only one of which was a woman. In low temperature situations such as scuba diving, some have thought women should maintain core temperature for longer periods of time than men because of more subcutaneous fat. Actually because women have more relative surface area, they cool faster. The possible increase in subcutaneous fat in women over men is of no significance until it is beyond 30%. There is no doubt that women trained in long distance running are more tolerant of heat stress than non-athlete women. Dr. Christine Well, at Arizona State University, is investigating the traditionally held concepts of dehydration and rehydration during the 24 h after severe exercise. Simple hemoconcentration and dilution concepts do not explain it all. The intercompartmental fluid shifts seem to be greater and more complicated. Her information may be helpful to the studies of diuresis and dehydration during diving.

Athletic performance during the menstrual cycle has been the subject of many papers and discussions in the past. Most reveal negligible changes throughout the cycle for most parameters investigated. Many have advocated exercise during the menstrual period for dysmenorrhea. For those in whom that has been a significant help, it is difficult to evaluate the exact mechanism. Certainly endorphin release would have to be considered and one would expect that only the chronically or the intensively exercising female would benefit, not the occasional or weekend athlete.

Not many women today are incapacitated with dysmenorrhea. On the other hand, therapy of the premenstrual syndrome is not yet satisfactory. Diving holds as much promise as anything suggested thus far.

Bone changes with zero gravity situations for men and women are about the same, i.e., density decreases with disuse, be it in bed, space or underwater. Exercise is preventive and curative in most situations. The postmenopausal woman and the hypoestrogenic amenorrheaic reproductive age woman may have a common problem, i.e., with a lack of estrogen they have a faster bone loss. It is thought by some that adequate exercise, calcium, and vitamin D may compensate. As mentioned before estrogen therapy under the protection of cyclic progesterone is becoming popular again. If the serious athletes won't go for the hormone therapy that may well be the best route. After all, who needs periods and pregnancy when climbing to the stars? On the other hand, if they want pregnancy and exercise, clomiphene, bromocriptine, and even naloxone, seem to hold promise if a reduction in exercise is not desirable.

Relatively high doses of progesterone have been suggested for some post-menopausal symptoms. Whether it would be considered for the hypoestrogenic athlete is doubtful. But certainly the high progesterone levels of pregnancy must be considered from an orthopedic point of view. As we know the resulting ligament and joint loosening of progesterone during pregnancy is a real problem for some women. So far these problems have not

been mentioned in the literature regarding strenuous exercise during pregnancy. It may well be that the increased muscle tone of good exercise is keeping the hip capsule problems and symphysis separation discomfort in check. It seems sensible to advise the pregnant athlete about the joint and ligament changes of the hips and symphysis during pregnancy. Certainly these changes are no problem for the pregnant diver underwater but could be a problem carrying heavy gear to a dive site or walking with tanks, backpack, and weights, especially on a pitching, rolling deck.

The problems of the potentially easily bent female (if research shows this to be true) or the pregnant diver are problems of any professional who dives (male or female). The diving companies are training old engineers, etc., to dive rather than train the young healthy diver to be an engineer. The astronauts are in their 40's and 50's before going into space. There are female physicians well trained in hyperbaric medicine. If tables can be varied for age, obesity, hypothermia, and exertion, certainly they can be recalculated for anything else including sex and pregnancy if necessary.

DIVING DURING PREGNANCY

If pregnancy occurs for the sport diver, a 9-month interruption in activities may not be devastating but what about the professional diver, the commercial diver, the navy diver in diving and salvage (school), or submarines, the astronauts (25% plus of astronauts in the future will be female), women facing altitude problems as pilots, nurses, doctors, photographers, etc., in the Air Force? What about the underwater photographer, actresses, resort guides, scuba instructors, spearfisherpeople, writers, editors, journalists of diving publications, and assorted scientists such as archaeologists, marine biologists, and oceanographers? A 9-month interruption in career or livelihood for these people may not be acceptable. So the need for knowledge about diving during pregnancy is real.

Extrapolation from Haldanian theory should allow diving to 30 fsw (feet seawater) for a pregnant woman but there is not human experience or research data to support such advice. According to sheep studies by Dr. William Fife at Texas A&M, no problems occur if depth is less than 41 fsw. It must be emphasized, however, that this does not prove that it is safe for humans.

For today's practicing physician the only absolute safe recommendation for the pregnant woman is: no flying or diving unless pressure is held to one atmosphere absolute. This is a difficult prescription, hopefully it will change in the near future. It is reported that in France no women are allowed in compression chambers regardless of age or pregnancy potential.

Any diver coming from depths below a critical level can bubble nitrogen but remain asymptomatic because the lung sifts out most bubbles. The fetus of the diving mother has a patent foremen ovale and most of the circulating blood bypasses the lungs, so even tiny bubbles are potentially dangerous arterial emboli. Another problem is that of decompression sickness (DCS). Should it occur in a pregnant diver, standard therapy would include the use of hyperbaric oxygen (HBO), with the potential of developing retrolental fibroplasia in the fetus. Thirdly, could HBO close the fetal ducti and open the pulmonary artery in humans? We know it has done so in some (but not

all) animal experiments. The above changes for both human and other animals seems to be dependent upon Po_2 in-utero. Although no one has seriously suggested a uterine artery autoregulation of Po_2, something like it must exist if the astounding work of the Russians is to be considered as reported at the International Conference on Hyperbaric Medicine at Moscow in September 1981. We know that elevated inspired Po_2 will cause a reduced uterine artery blood flow.

From the abstracts of the Russian papers, approximately 800 pregnant women were treated in pressure chambers with or without HBO. Pressures ranged from 1.2 to 3.0 ATA for varying times and numbers of treatments in a course. Some of the women delivered in chambers, and were decompressed at varying times postpartum. There was follow-up of the children from 1 d to 6 yr. Generally they report satisfactory results. Although the requested complete papers have not yet been seen and much criticism of other cultures is always possible, it is hard to conceive of 800 people being treated if there were many or even any early significant problems and certainly no one could or would overlook blindness in their offspring.

They were treating maternal congenital and acquired heart disease, prosthetic valve problems, pulmonary artery thrombosis, pulmonary hypertension, myocardial infarction, disorders of reproductive function in women, premature labor, postmaturity, poor placental functioning, Rh incompatibility, anemia, uterine inertia, hepatic and renal disease, hypertensive disease, diabetes, etc.

The concerns we in this country have about treating decompression sickness in pregnant women, such as premature closure of the ductus, decreased placental perfusion, increase in pulmonary artery pressure, and retrolental fibroplasia are not even suggested in the Russian abstracts.

With the exception of chicks, hamsters, guinea pigs, and rabbits, animal experiments looking for DCS in the fetus prior to its manifestation in the mother show the fetus to be quite resistant to DCS.

Sheep, goat, dog, and rat fetuses show no evidence of damage to the fetus before the mother, with the exception of Dr. William Fife's original work on sheep. Other investigators felt the instrumentation in his experiment was the cause of bubbling.

On the other hand, in March 1985, Powell Smith reported in the *Journal of Biomedical Research* that Dr. Fife's original work was correct in that they produced essentially the same results while detecting fetal and maternal bubbles, non-invasively (transcutaneously). Therefore, the possibility of decompression sickness in the fetus before symptoms occur in the mother is possible, at least in sheep and goats.

The retrolental fibroplasia found in rabbits, which are particularly sensitive to oxygen and eye problems, has not been found in other animal.

Retrospective studies have been inconclusive or statistically not significant, as far as teratogenesis in the human or increase in DCS in women in general or specifically in pregnant women.

The prematurity rate of 44.6% of the Ama divers of Japan and Korea always mentioned in articles dealing with diving and pregnancy, does not really apply, in that they are free divers who work very, very hard throughout their entire pregnancy. Weight was the only criterion for prematurity, so, "small for gestational age babies," is probably a more appropriate term. Certainly whether premature or SGA, it was not related to compressed air and doubtfully related to pressure in that the average dive is only to 30 fsw and not below 60 fsw. Sometimes these divers are confused with the Tuomota Pearl divers who go to 90 to 120 ft. Almost all the Tuomota are male divers, whereas, of course, the Ama are female, except for Japanese Ama, who now are 65% male.

There are no published prospective studies regarding maximal exercise during pregnancy. Advocates of exercise during pregnancy and all published advice have suggested exercise cease before fatigue or discomfort. Most pulmonary function studies during pregnancy were done on the non-exercising patient. Yet some of the anatomical and physiological changes of the upper and lower respiratory tract must be kept in mind by physicians caring for the pregnant athlete and certainly if they are doing compressed gas diving or even free diving. A few of the changes are: 1) Tidal volume increases from 450cc to 600cc at the expense of expiratory reserve volume (questionably good if a diver is pregnant). 2) Closing volumes increase with age, smoking, and in the upright and supine positions during pregnancy. During airway closure, lung perfusion exceed pulmonary ventilation in the effective areas of the lung. The resulting hypoxemia may partially explain the variations in maternal arterial tensions during pregnancy. Does this mean an increased chance of air trapping and pneumothorax for the pregnant diver or should pregnant women dive to cleanse their lungs? 3) Total pulmonary resistance (airway resistance plus tissue resistance) decreases 50% during pregnancy. Airway resistance is dependent upon the rate of flow, density, and viscosity of the gas around the anatomic state of the airway. As we know, density and viscosity of the gases increase and the rate of flow deceases with increasing depth and pressure. It would therefore seem that at least deep diving during pregnancy may increase total pulmonary resistance slightly. The tissue resistance increase is thought to be a progesterone effect upon the bronchomotor tone.

The increased blood flow of pregnancy might increase the rate of gas transferred to and from tissue beds, which could make diving safer during pregnancy. On the other hand, a faster gas take-up in slow tissue could make even shallow diving a greater hazard.

The question of increased body fat during pregnancy is frequently mentioned as a potential increase in the hazards of diving during pregnancy. There is no research on this.

After a dive, pressure on the iliacs and inferior vena cava might reduce blood flow from the lower extremities of a pregnant diver which might

interfere with the elimination of gas and enhance the possibility of decompression sickness.

The inferior vena cava syndrome with supine hypotension, as well as tight fitting wet suits, weights, weight belts, or buoyancy control gear have been considered as potential hazards. This could be true on the surface, but should be well compensated for by zero gravity of the skillful diver underwater.

Heavy exercise, stress, or anything increasing catecholamine levels are thought to reduce uterine artery blood flow at least temporarily. Just as many women do aerobics, jog, swim, or bicycle well into their third trimester of pregnancy without apparent fetal or personal compromise. Probably no one feels that a quiet, relaxed, uneventful dive can impose a detrimental cardiovascular stress on a pregnant diver or fetus. Yet who can guarantee any dive to be quiet, relaxed, and uneventful?

Many obstetricians encourage physical activity during pregnancy since exercise increases cardiac stroke volume, oxygen extraction, and cardiac output. As long as exercise is not so strenuous as to decrease uterine artery blood flow or increase body core temperatures to excess (which can cause teratogenesis in the first trimester and premature labor later in pregnancy), it is advantageous since the increased "muscle tone of the well conditioned women will better tolerate the work of labor. However, scuba diving involves inherent dangers beyond general exercise and should be considered separately."

In any discussion of diving and pregnancy, hypoxia, both relative and absolute is usually considered. Sheep and human fetus resistance to hypoxia is well recognized. The left shift of the oxygen dissociation curve and the diving reflex in most fetuses is well known even though it is not as pronounced as in some diving mammals. The Weddel seal also changes from glucose to lactate metabolism under hypoxia except for the brain which continues glucose metabolism. Regardless of the above, the nagging knowledge of the role of asphyxia in hyaline membrane disease cannot be ignored.

Obviously there are not many dogmatic positions regarding diving and pregnancy, except -- stay at one ATA in spite of the Russian information. Most feel some exercise in a healthy woman with an uncompromised pregnancy is good especially if exercise was regular before conception. It would seem, at least in research, we should begin to shed some of our paranoia about women underwater when pregnant and look at the possibility of a positive experience, if for no other reason that to consider the use of hyperbaric oxygen therapy for certain high risk obstetrical patients.

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DISCUSSION FOLLOWING PRESENTATION BY DR. MAGALETTA

HONG: George, this increase in prolactin during hyperbaric exposure is interesting. What do we know about the functions of prolactin, and what consequence does prolactin have?

MAGALETTA: Prolactin is going to decrease pituitary output, then estrogen and progesterone production. Then amenorrhea. Then possibly lactation.

HONG: What about the anti-diuretic effect? Is it true?

MAGALETTA: Prolactin?

HONG: Prolactin. In some other animals it has an antidiuretic effect.

MAGALETTA: Not that I know of--not antidiuretic.

HONG: No, prolactin. In fact, I once theorized that the prolactin response is related to the hyperbaric diuresis; but my findings were not consistent. That is why I withdrew my own theory. Now I was interested in seeing yours. You are not the only one. This may have some consequence in terms of body water balance. That is my angle.

MAGALETTA: An increase in prolactin can occur with almost any exercise. The interesting thing in Willson's paper is that these women developed their hyper-prolactinemia with no exercise at all. The point I think to be made is that a dive in a chamber, regardless of exercise, has all the blood chemistry looks of an exercise episode. The only one that it doesn't have is the changes in cortisol which you see when in high level competition.

HONG: One more question. Did the Russians give their rationale for the treatment of miscarriage? Because the trouble is that people try things without a rationale, and I think it is dangerous.

MAGALETTA: That is exactly the point I was making in that the people in this country, might not accept the work. If you are going to try treating threatened abortions, then forget all your work because you will be considered kooky. And that is not valid.

HONG: The Russians didn't give any?

MAGALETTA: They just did it. I don't think that they got any good results with it. What they did say was that no one was any worse off than they were before.

MATHIAS: Most of the drug research is in the first 3 months of pregnancy with regards to the fetus generally. I wonder if there are enough data in terms of high pressure gases regarding the stage of pregnancy. You mentioned hyaline membrane disease which is talked about usually I think in the later months of pregnancy?

MAGALETTA: I don't think there are enough data. I really think that if you don't have teratogenesis with diving, early in pregnancy, and that needs to be proven, I think you will see greater damage later in pregnancy. But there are no data to support this that I know of. Does anybody else?

FIFE: There are some data that show, for example, that you can create teratogenesis. This, for those of you who don't happen to know it, is abnormal development. You can develop that, for example, in chick eggs. I have done that myself. There are some reports also that when they put pregnant rats and guinea pigs into chambers on pure oxygen, they had some abnormalities in the fetuses. There have been quite a few pregnant women who have been treated in a chamber for one reason or another and there are no reports of any abnormalities that could have resulted from that. In fact, I know of no woman who has had any abnormalities from any cause having been treated with hyperbaric oxygen. There is no evidence of hyaline membrane disease in the fetus after the mother underwent hyperbaric oxygen.

In fact, I think I mentioned I took pregnant sheep and put them in daily 90-minute oxygen exposures for 30 days straight on 60 feet for the 20 and 5 cycle. The fetuses had normal eyes at birth and for the following 30 days at least. So I guess I consider retrolental fiberplasia no problem. For those of you who don't know, it is blindness that occurs due to blood vessels developing in front of the retina which block out the light.

MAGALETTA: The reason the problem exists is that they get hyperoxic, and you can produce this in a prematurely born baby in the nursery, just give it too much oxygen, and they develop this blindness.

So the concern is, will that also happen in the baby in utero whose mother is getting hyperbaric oxygen because of decompression sickness. Here again, maybe the uterine artery cuts down, you don't get the blood flow to

the fetus, the fetus or the uterus has its own oxygen regulation. That would be the ideal situation. We can't prove it one way or the other.

FIFE: We and others have measured the fetal arterial oxygen in sheep. When the mother is on hyperbaric oxygen, unless it is more than 500 mm Hg, the baby's arterial Po_2 doesn't go up significantly.

NUNNELEY: I reviewed the literature to see what it was, and it seems to be associated with women who have had a fever, a substantial temperature elevation over a period of more than a day. The Finns then looked very carefully at their data on women who used the sauna and bathe regularly. They find no incidence of neural tube defect. In fact, it is lower in Finland than it is in other places.

My feeling is that a short burst of hyperthermia, such as a diver might encounter in a wetsuit during a limited dive in hot water probably would not produce this problem.

MAGALETTA: I agree with you. You mentioned neural tube defects. It is not just that. They are concerned with other teratogenesis.

NUNNELEY: But that is an example.

MAGALETTA: Right. Where the fear comes from is the work that has been done in other animals. And again, we have no human work to substantiate it.

There is another observation that probably is correct. There was this hyperthermia later in pregnancy, and for some reason, if there is hyperthermia, or certain other activity during the latter part of pregnancy, you run the risk of increasing norepinephrine over epinephrine. When you raise dopamine levels, what are you going to get? Norepinephrine rises over epinephrin. You would like to keep it even if you could. Epinephrine is what keeps the uterus calm. And epinephrine like drugs are the things that we use to stop premature labor in some women. So the body has its own method of stopping this. But it is norepinephrine that increases uterine activity. That is one we are concerned about with hyperthermia later in pregnancy.

HONG: During cold water diving I think norepinephrine is released.

CLARK: This is irrelevant, but I dived quite deep in three of my pregnancies right up until just before I delivered, and I had no problems.

But I wanted to ask a question. What do you think of exercising women who want to keep in shape, especially for diving? I used to do the Royal Canadian exercises in which they say stop when you start to feel tired and just exercise as long as it is comfortable for you, versus the Jane Fonda tapes which really push you and tell you, don't stop, you know, make it burn. That is one of her favorite terms. You work your muscle until it actually feels like it is burning. Then at that point, there is at least maybe it is psychological, but I have the feeling that at that point I am really working the muscle. It is pushing it.

MAGALETTA: It depends on what muscle you are talking about. If it is upper body muscles, I think you can push it as long as you are not pushing your cardiovascular system beyond the point that it should be, whether you are pregnant or whether you are not pregnant. If you are pregnant I don't think you are able to do that. I don't think your body will allow it. It is possible when you are not pregnant.

During pregnancy lower body exercises, and the thing I find the most difficult with Jane Fonda is the bouncing and this sort of thing. That is fine as long as it is not going to separate the symphysis or increase your hip problems. If you are pregnant, that can really be a problem. If you are used to this sort of thing, apparently it is not the same problem as if you are starting it new. I never recommend anybody starting aerobics just because they got pregnant and they want to be in as good shape as they can. I say, what sports, what activities do you do routinely and you are good at. Some of them I wont let them continue. I think horseback riding is one, bicycle riding is another, and the only reason for it is your balance changes rapidly during pregnancy, and your chances of falling off the horse, falling off the bike, increase as the pregnancy goes on. A stationary bike is fine.

But if they want to start new exercising even if they previously have been doing all sorts of exercises, walking I think is your best bet. It is a super exercise if you walk fast enough. First of all, if you walk 30 minutes 3 to 5 times a week, it is good exercise for anybody. If you walk fast enough to become a little bit short of breath, so that you can say this to a pregnant woman, "Too short of breath to sing, not so short of breath that you can't talk to someone." More than likely your target heart rate is going to be just about in the area you want.

The difference that will occur when pregnant, is that the mileage is going to be cut down. Keep it at 30 minutes. Who cares how far you go. It is the 30 minutes with your heart rate at a certain level that is going to do the most good.

When you are 120 years of age, the same thing applies. The mileage is going to be cut down as time goes on, but the 30 minutes will stay there, and your heart rate is going to stay there. That is all you are looking for. Does that make sense?

FIFE: Dr. Clark, could you tell us how deep you dove? You probably kept careful records of how deep you dove during those pregnancies. Do you have any remembrance of what that was?

CLARK: Eighty feet in the last pregnancy, and over 100 feet at various times, but near the end. I actually felt so much more comfortable in the water diving during late pregnancy.

FIFE: Did you make more than one dive during each pregnancy?

CLARK: Oh, yes. During three of my pregnancies I dived regularly.

FIFE: With multiple dives deeper than 100 feet.

CLARK: Yes.

FIFE: Had you been diving prior to your pregnancy regularly?

CLARK: Oh, yes.

WACHHOLZ: Do you think that there is any reason to suspect that acclimation had anything to do with this?

MAGALETTA: Of course, it may be safe for the mother. I don't know about the fetus.

INNES: The other factor is, none of the studies showed that if they took 100 people who were pregnant all hundred people are going to get hurt.

FIFE: The probabilities are rather small in fact.

INNES: Exactly. So she fell in the normal range of the curve. It is just that some people don't fall in that normal.

CLARK: Well, that was a long time ago, of course. When Dr. Magaletta starts to mention the 120-year-old diver, that is the one that interests me. I have always exercised regularly, and not pushing it. Keeping it up is what I would like to do to stay in good shape so I can dive when I am 120.

INNES: I just have one question both to George and to Dr. Morgan. I was on a college swim team when I was in college, and subjectively, I felt that the women that I was around on the team were substantially more aggressive than the average non-athlete, and we always related this to the increase in testosterone because of the high levels of exercise.

But maybe it was entirely subjective. Have there ever been any studies where they monitored the increase of testosterone and cross referenced it with psychological studies?

MORGAN: Not to my knowledge.

INNES: Then of course there were always people who were taking synthetic drugs on purpose. We had a lot of that which went on. They would purposely take the synthetic drugs and would take the testosterone in hopes that we would increase muscle mass. They not only got more aggressive, they had a lot of other changes. I have just always wondered if that was purely subjective on our part, that we just happened to be leading a more active lifestyle, and it was totally subjective, or if in fact the increase in testosterone from athletic did change our personality profile.

MORGAN: Research on personality of female athletes indicates that they score significantly higher on standardized measures of aggression than do non-athletes. A similar finding has been observed when male athletes and non-athletes have been compared.

Again though, I think that most of the work would suggest an initial difference in athletes and non-athletes as opposed to change because of sport participation. In other words, evidence suggests that the more aggressive young men and women become athletes as opposed to the sport changing them. It is only fair to say, however, that we need more longitudinal research on this topic.

Since you raised the question about the female swimmer, as well as the issue of whether or not men and women differ with respect to overtraining and overdoing it, in our women athletes, they can become overtrained and stale to the same degree as do the men if they are exposed to an intense training program. The training load, of course, is imposed on the swimmer by his or her coach. The stress is not self-imposed.

INNES: That is what I was just going to say. At the college level at least you don't get any choice about what your training is going to be.

MAGALETTA: I don't think there is any doubt though that the female runner once she is addicted or committed to so many miles a week, and she does that for a certain length of time, it becomes the same as brushing your teeth. It is going to get done one way or another. Many athletes are that type of person. They don't stop when it is time to stop. They don't listen to their body. They go out and they get damaged. I am not talking about the ones that are in college or even in competition. That is what they want to do. They are not competing. They are competing with themselves. Those people do not listen to their body.

WACHHOLZ: George, you mentioned earlier that you need to take special considerations in evaluating the professional diver who becomes pregnant. What sort of restrictions do you place on them when you allow them to dive? How much diving do you allow them?

MAGALETTA: Please let me correct that. I don't allow them to dive. What I do is I say, we cannot guarantee it is safe for you to dive. We are frightened it might not be safe for you to dive. But if you do dive, make sure you let me know, I want to watch you and study you, because maybe we can get some information out of this.

What I was hinting at someplace else was, we take old doctors, we take old engineers, and teach them to dive, or put them under water at any age. Each dive company has its own dive tables. Dr. Fife makes up tables to fit a particular need. I can't see why we can't make tables for pregnant women or whatever.

FIFE: I would like to get off my making up tables right now for diving companies and make up tables only for 68-year-old men.

I have another remark, and that is that I have found out that at my age physical conditioning lasts just 24 hours. You mentioned overtraining and overconditioning. The literature shows that when a person starts to develop and exercise program the blood lactic acid levels rise, and then as they

become trained at that level they don't rise that much for the same given level of exercise. So far, am I right?

MORGAN: That is true for both absolute and relevant work.

FIFE: I have also read that when they get overtrained, now suddenly the lactic acid levels start to rise again with that same level of exercise. Is that true?

MORGAN: Yes, that is true, and resting levels of CPK (creatine phospho-kinase. ed.) are elevated as well.

FIFE: So there is a chemical way of assessing when this overtraining is reached?

MORGAN: Some of us think so. It has been reported that East Germans monitor their endurance athletes daily by taking an earlobe blood sample of their swimmers and then basing the next day's workout on that morning CPK value.

FIFE: It may be of interest to divers, too.

LEGAL ASPECTS OF DIVING

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There's something about the legal aspect of diving that leads everybody to have questions and maybe we can have time for a question and answer period.

Based on current statistics, it's accurate to state that recreational diving is a safe sport today. Even if you use the worst 0.03 incidence of bends, you've got a pretty low rate for people that are making 80,000 dives in your survey.

The problem is that when there is injury in scuba diving, there's a great chance that it's going to be severe or fatal. And that's very often the case. And unfortunately, in our society generally people sue or their survivors sue after an accident. I am going to talk a little bit about this because it's getting to be such a hot issue now with state legislatures trying to limit the amount of awards to victims, and whether it's the fault of plaintiffs' attorneys or whether it's the fault of the insurance companies that are building up their reserves too much, the cost of suits are very high.

But the point of the matter is that if somebody gets "bent" or somebody gets hurt, they're probably going to sue somebody and everybody. And that's just the nature of our society today. And we can certainly all talk for a lot longer about why it is so.

I know I've got a lot of medical doctors here. And generally, when I'm talking to medical doctors, I find that this is a very sensitive topic with them. They tend to go right through the roof whenever you talk about lawsuits. And I guess it's because they feel like they are a sector of society that has been victimized by tort liability. That's what we're dealing with today, an area of the law that is called torts, or negligence. It involves the concept of negligence, or civil liability which is another way to refer to it. I'm going to generally outline for you what a tort is, how a lawsuit gets started, and what happens from there.

There's not any yes or no answer to anything in the law and particularly in personal injury suits. It's always going to be a question of the lawyers applying a certain basic formula to a situation. And often it's just up to the creativeness of the lawyer.

What the lawyer is going to be trying to do is not necessarily get a judgment against the person who is most at fault, but to get a judgment against the person who has insurance because those are where the deep pockets are. It doesn't do a lawyer or his client any good to get a

judgment against an instructor whose insurance policy has expired and he makes 25 grand a yr.

It might do them a lot of good to get the manufacturer, such as Scuba Pro, because Scuba Pro probably has some net worth or has liability insurance. It's an aspect of tort suits that lay people find particularly offensive. But it's the reality of what's going on.

First of all, basically, our legal system is a codification of how individuals are expected to behave, or our civil legal system is a codification of how individuals are expected to behave in relation to one another. Implicit in this definition is that should someone not live up to this expectation, certain consequences are going to result to that person. When you don't live up to the expectation that this Great Society has decided that you should live up to, it says you've committed a civil wrong. Civil wrongs are called torts.

Negligence basically deals with what we call avoidable accidents. These are accidents that should have been anticipated and prevented by taking reasonable precautions. It's important to understand that intent is irrelevant. It doesn't matter that Scuba Pro didn't want that automatic inflater to not work. It's totally irrelevant.

Ignorance of the law is irrelevant. It doesn't matter that you didn't think you could get sued for that. Negligence can be further defined as creating an unreasonable risk. The key word here is "unreasonable."

There are law libraries, entire floors of law libraries, that are filled with books about what is reasonable. That one word, "reasonable," is the backbone of the law of torts. What has developed is some general ideas forming a concept of reasonableness.

First of all, in order for something to be unreasonable, the civil wrong must have been to some degree foreseeable such that a reasonably prudent person, in hindsight sitting on that boat, would have thought that the accident might have occurred. For example, go back to the Scuba Pro, the automatic inflater doesn't work. It is reasonable to assume that Scuba Pro has thought there is a possibility that this automatic inflater might not work and to have taken steps to prevent the automatic inflater from failing. There's a certain amount of due care in preventing accidents. I'm going to elaborate more on what is due care in the law of torts.

But right now, I just want to state that you have to guard against all unreasonable risks of harm that can be reasonably anticipated. I know this is a matter of semantics, but this is what lawyers do, and this is what the law of torts is. It's a big word game in determining what is reasonable and what is not reasonable.

But it's important to realize that you aren't liable for all risks of harm. There does come a point where you're out of the civil liability area and into an area of risk of living in today's world. For example, if you're at a parade and you get jostled in the street while the parade is passing,

it is probably not something that's recoverable in a court of law. There are just some things that are going to happen to you by walking around in society, and the courts are not going to redress it. But more and more today, the area of what is not redressable is getting smaller, and smaller, and smaller.

I've tried to come up with some examples that might show the difference between male and female students in your class and how the legal aspects might be different between a woman diver and a male diver. I do think that generally it's going to be the same. But I'm going to talk about some specific things that have come to mind with regard to women. One problem is that most of the female students who have come through my classes are taking the course because their boyfriend or their husband want them to take it. They are not physically fit. Some of them really don't want to be there in the first place. I pick up on this all the time. And if you pick up on that, and that is to some degree average in classes everywhere, then it's going to be held by a court of law that an instructor should be aware of that and should take that into consideration. Moving tanks around could cause foreseeable injury to some women.

How does the law establish a standard of care? Basically, conduct is measured. It's always going to be measured in a tort case against a fictitious ideal person who always uses due care and always acts prudently in any circumstance. It's what is called the reasonably prudent person. What would the reasonably prudent person have done? That is the key question.

In our case, with scuba diving, it's going to be the reasonably prudent scuba diver, the reasonably prudent scuba instructor. This is the standard you're going to be judged against. This fictitious person is going to take on any of your superior mental capabilities that you may have and, likewise, any of your deficiencies.

If any of the doctors here have ever been sued, and you were in a subspecialty, you were not judged by the average family practitioner. If you've had specialty training, say, in orthopedic surgery of the hand, then you're going to be judged as the reasonably prudent orthopedic surgeon with this specialty training in hands.

In setting up this fictitious standard of care, usually the number one thing the courts are going to do is look at your peer group. The courts will also look at whether there are any standards in the industry. In scuba instruction and scuba diving the first place the courts are going to go to is the YMCA, NAUI, and the PADT scuba instructor standards. These organizations set the standards in the industry.

I'm going to talk more about adhering to these standards later. The courts are also going to look for state/municipal laws. Right now, there are not a lot of state, Federal, or municipal laws governing scuba diving. It's coming, though. Mostly because we've got people uninformed about scuba diving screaming that there's hundreds of scuba diving accidents. And we know that isn't true. But it's like a plane crash, you have one plane crash

and everybody tells you flying is unsafe when it's probably one of the safest means of transportation around.

The same thing with scuba diving. All you have to do is have one person die from air embolism and all of a sudden it's an unsafe sport, and all of a sudden the Federal Government wants to get in and start regulating it. I think, unfortunately, it may be coming to Federal regulation basically because we're starting to have certifying agencies come out that are not adhering to the traditional standards, and we're having people now becoming instructors in a weekend when they've less than 20 personal dives. They're running classes, and people are getting hurt in these classes. And those people that get hurt, or their relatives, then run back to their Congressmen and say, "This shouldn't have happened. My son or daughter should not have been able to take a scuba class."

I think we're going to eventually move toward national certification of scuba divers just like we have state certification of hairdressers. I think the only thing that can stop it and that has stopped it this long is that basically the old and known certifying agencies have done a pretty good job of regulating themselves.

The breakdown has come in the last 5 to 6 years when the profit motive of scuba diving has gone up. And business is what's guiding--profit is what's guiding the scuba diving industry today. And a lot of times, that's what's determining whether you certify a student or not.

My personal experience as a non-profit independent instructor reflects standards lowered for business reasons. I want to keep my fitness standards high, but my students complain to the dive shop, "She makes us swim four laps every class. The dive shop down the street doesn't make their students do that."

So then, when I see my dive shop owner, who sees students wishing they had gone down the street, he says, "Hey, Susan, you know, why don't you just make them swim two laps." I say, "NAUI standards or YMCA standards, or PADT standards say they have to swim four laps." And the owner says, "Well, so what?"

That's what I hear. But because of this lowering of standards, you're going to be having the Federal Government come in and enforce standards. So state/municipal laws are very limited or non-existent now, but could be significant in time. Courts will look to what the expert literature says. There are many publications. And lastly, they'll look to expert opinion.

Lawyers will get other scuba instructors to testify at your trial whether what you did was or was not what a reasonably prudent scuba instructor would do. Because of the hindsight factor that you have in a court of law, what may have seemed proper conduct to you at the time can be judged much later in time under this legal scrutiny to have not been due care.

This is another tough fact to accept. It's very difficult to accept that a trial is going to be hindsight judgment by a fictitious scuba instructor. So I can't emphasize enough to you to try and take care when you're teaching your classes.

Any basic tort action has four stages that have to be met to go to the jury. If you don't meet these four stages, the defense is going to move for a directed verdict. If granted, the judge means that the burden of proof wasn't met, and a dismissal will result. The case will not go to the jury for a decision.

The first stage is that the duty has to be established. There has to be some kind of legal relationship between the person bringing the lawsuit and the person getting sued. I can sue the guy that lives in the house next to this one. But if I do, his attorney can file a motion to have the lawsuit dismissed because there's no legal relationship between myself and that person next door, provided there has been no contact whatsoever between us. There has to be some duty out there that's established. For example, my neighbor's tree fell on my house. In scuba diving, it's a duty to use reasonable care in teaching you scuba classes. Back to the fictitious reasonably prudent scuba instructor.

It's important to realize that students are relying on their instructors for protection and safety. It's almost like a patient going into a doctor's office and that patient is relying on the doctor to tell them what is wrong with them and how to get well.

Some observations about duty and scuba instructors. You're going to be judged by your peer group. Therefore, a scuba instructor should possess and use that degree of knowledge, ability and skill usually possessed by competent instructors in the field of scuba instruction. If you're a scuba instructor, it's your duty to get out there and stay abreast of what's happening in your field. Your conduct is going to be measured against the commonly accepted standards of instruction of national diving organizations. You have to exercise the same degree of care that a reasonably prudent scuba instructor would.

I want to mention another feature in connection with duties. You're going to be judged on the "state of the art" concept. For example, I now get sued or somebody in this room gets sued because I failed to state that women had more susceptibility to the bends or I failed to state that women should take 10 min off their dive tables. My student is certified and the following weekend after she's certified she goes diving at the oil rigs in the Gulf of Mexico. She goes to 60 ft for 60 min, she gets bent, and she ends up with residual paralysis. She then sues me, the dive shop, the boat owner, and probably the people that made the oil rig. Ultimately, liability is assessed against me because I failed to tell her to cut time off the tables. At the trial I introduce evidence that new research indicates that women have no greater susceptibility to the bends than men. Her lawyer would argue that even though today the experts are saying maybe there is no difference between women and men's susceptibility to the bends, at the time that I was teaching my class it was state-of-the-art that I should be

telling female students that women had a greater susceptibility. You're going to be judged by the state-of-the-art at the time, not by new advances subsequent to the date of the accident.

I can't emphasize enough the importance of keeping to the standards of your certifying agency. Most of you who are instructors have insurance and the agencies require you to have insurance.

There is a provision in your insurance policy which states if you don't adhere to the standards, the policy is inapplicable. This means if your agency requires your students to make five open water dives, you students should make five open water dives, not four open water dives and one snorkel dive. If your agencies' standards require that you not dive deeper than 60 ft with students on their first dive, don't dive deeper than 60 ft. I know as well as anybody the pressure that instructors are under due to the business and profit factors mentioned earlier. I want to make you aware that your insurance policy is not going to apply if you don't adhere to the standards, including student to instructor ratios. I see that standard violated all the time.

I've seen people getting in the water seven to one with no assistant instructor in the water. And their logic is, "I trained these students. There are only 10 people in the class and they were all really good students. They're all really strong." That's fine. But there's a big difference between being in a pool and being in open water. You still don't know how those students are going to react. Constant attentiveness. I consider it extremely important for instructors to be constantly aware of students and being on the spot when they have a problem.

The second stage of a lawsuit is violating the duty. If you adhere to the standards and you do everything right, there's no breach of a duty. Then there's not going to be any liability on your part if an unforeseen, unexplainable accident occurs. There is an area of tort law called strict liability, but it is not applicable to scuba diving. For example, suppose a woman jumps in the water and everything is fine and perfect, and you do everything 100 percent right and that person in the water has a heart attack. You immediately pull her out of the water and start CPR, you get the Coast Guard on the phone, and you get her to shore, and she dies anyway. This woman had no prior heart condition, ever. She was not nervous, panicky, or exhibiting any unusual behavior. This was just an unknown, unusual event and she just happened to have a heart attack when she jumped in the water, for unknown reasons, and there was no indication to tell you that was going to happen. The instructor did not breach any duty. She just happened to jump in the water and have a heart attack. You're not liable. Or I predict with 95 percent certainty you will not be liable. Juries and judges make mistakes.

In breaching a duty, it could also be something that you failed to do as well as something that you do inadequately or wrong. For example, if you fail to put the dive flag out, as you're required under most state/coast guard laws and a diver ascends and is run over by a motorboat and is injured, you have violated a duty.

The third stage is proximate cause. The harm to the diver must be the natural and probably consequence or result of the instructor's negligent conduct. For example, you failed to put a dive flag out, you took your class into the water, and one of the students gets bitten by a rare fish and dies. You are sued for failing to put the dive flag out. That is not a reasonable consequence of the breach of your duty to put a dive flag out. Another example might be if a diver gets bent and the injury gets worse because it took time for him or her to get to a chamber. You tried to do everything that you could to prevent the accident. Later it is brought into evidence that you failed to have the dive flag out. Failing to put the dive flag out has no causal relationship to a diver getting the bends. Location of chambers is not within the instructor's control. In other words, the injury has to be proximately caused by the breach of the duty.

This causation factor is a problem in emotional distress accidents. They're starting to have lawsuits for emotional distress suffered by the person sitting on the beach who sees somebody get run over by a motorboat.

The question is: Is that caused by the person failing to put out the dive flag? Is it too remote? Is it foreseeable that somebody is going to be sitting on the beach watching divers and is going to view this accident? A lot of lawsuits are won on the causation stage. You have a duty, and you have a breach of duty. But that breach of duty isn't what caused the injury that this particular plaintiff suffered.

The fourth and last stage is damages. There has to be some kind of damages. There has to be some legally recognizable injury to a victim for damages to be recoverable. For example, if you go in the water and you fail to put a dive flag out, and when you're getting back on board you get a very minor scratch from a pointed object sticking out. It heals in 1 day and never bled. There's no damages there. If you can't show any monetary loss or any pain and suffering, then there will be no damages awarded. You don't just get money because there happened to be a duty and a breach of a duty and you met causation. There has to be some damages there.

Physical injury, damages to property. Emotional injury is usually not compensated by itself although it is an emerging area as mentioned previously. You also have to have a right to these damages. For example, this is a critical factor if you're living together with somebody rather than being married. Wrongful death actions require that there be some kind of legal relationship between you and the person that was killed. And they've had some pretty unfortunate decisions come down where people have lived together for 20 or 30 years but weren't married. Because there is no recognized legal relationship, they had no right to bring a wrongful death action when they lost that individual.

Another thing that's going to be brought out in lawsuits today is comparative or contributory negligence. This is a new developing area--I say "new," during the last 5 to 7 years it has emerged. Louisiana recently enacted it into law. Most other states have had it. California has probably had it for 10 years. This legal theory takes into account the conduct of the injured person. The conduct will be scrutinized. This is

very useful in limiting liability in personal injury suits. For example, if someone dives with you and you take her to 180 ft and keep her there for 35 min. On surfacing she shows symptoms of the bends, and you tell her that she's probably got the bends. You tell her she needs to go to a chamber, and that the Coast Guard needs to be called. The person says, "Oh, no. I'm fine. I don't want to go to a chamber. No way." The next morning it's worse, and you get her to a chamber. Now, she's got residual paralysis that she might not have had if she had gone to a chamber when you told her to go. Then, you're going to have some comparative or contributory negligence issues.

I support this development in the law because what used to happen before you had contributory negligence is you had a theory called assumption of the risk. And if the defendants could show that the plaintiff had assumed the risk, the plaintiff was out of court. He lost his case completely. You either won everything or you lost everything.

Now what they'll say is, "Okay, plaintiff; you did get injured and that's worth $100,000. But we think you contributed to your injury 50 percent so we're going to cut the award by 50 percent and you only get $50,000." It's a way of victims being compensated, yet, at the same time, taking into consideration their own behavior.

I would now like to cover some common exposure areas in case law regarding scuba diving and personal injury suits. One area is medical eligibility. It is very important that you get your students to fill out medical history forms. NAUT, YMCA, and PADI print them. You can request them from the certifying agencies. Make sure students fill them out and then make sure you read them after students have filled them out. Don't just collect them and stick them in a file, "Class No. 3, 1985" somewhere. Read them. And if you see anything that sparks your thinking, I suggest you have somebody as a contact in your area that you can review questionable students with. I'm real fortunate in the area that I live in. We have an anesthesiologist who is also trained in hyperbarics through the Navy. Most medical doctors are not trained in hyperbarics. They don't understand the hyperbaric environment and certainly you shouldn't assume that a doctor understands the hyperbaric environment.

Another area to review is the age factor. If you've got somebody over 40 you should require them to get a physical. I know they don't like it because it costs them $50 or $60 to get a physical. I also use my own best judgment as to whether I think they ought to actually get a physical based on what their medical history says. I call up one hyperbaric specialist, Dr. Alan Ostrowe, and I say, "Alan, this guy has this factor and this factor and this factor. Do you think I ought to make him come get a physical?"

Usually, I find that physicians who are not hyperbaric trained are ultraconservative. If you had an ear problem when you were three, they'll recommend you don't dive ever. Maybe there's no reason for the individual not to dive. You might have him/her go see and ENT doctor who does have some hyperbaric training who can knowledgeably review the case.

Ultimately, it's up to the instructor to decide who he or she wants to teach. I had one student who was about 6'4" and weighed probably 320 pounds. I didn't want to teach him. He was, other than being extremely overweight, in fairly good health. But I know that if I had that student in the open water and he panicked, I'm going to try to get away so I can save myself. And so, look at your own limitation, particularly the female instructors. I don't put myself in the water with somebody that I don't feel I can rescue as well as myself. I can tell my students, "Your first concern is you. Take care of yourself before you start rescuing somebody else." But as an instructor, that's not true. I have a duty, when I get into the water, to make sure those students are safe and kept safe while they're in the water. So ultimately, it's up to the instructor.

RELEASES

I know that three major certifying agencies have printed release forms you can purchase. These releases are written as blanket, all encompassing releases. I strongly recommend using them. But it doesn't do any good to have the releases signed if the student testifies in court that they signed the release while they were signing four other pages and writing out the checks for the course. You need to save the releases until opening night of the course, and stop the class and instruct everyone to read them. Then have the students sign it. If they go to trial and they testify, "Yes, I signed it but I didn't read it," -- I, as a defense lawyer at that point, would say, "The person was 18 years old. They had a duty to read it, and they were clearly instructed to read it." I could call other students as witnesses to verify this fact.

Releases are not foolproof but they are very, very helpful in formulating a defense. The insurance companies will be very pleased if you have a signed release. Be aware that the circumstances surrounding the signing will be scrutinized.

I recommend that you have some screening process of the students at the outset and throughout the course. I think you have to recognize the perspective that the average woman is coming from. From the screening process -- and I'm going to limit this primarily to women rather than men because of the orientation of our lecture -- the question is going to be, "Is the diver capable of handling the physical and psychological demands of diving?"

I think, without question, they are physically able to do it. The psychological problems are a lot greater. For example, Bunny Key, currently a commercial diver, went through her basic diving course and did not know how to put her diving gear together. She took the course in 1969. She was the only female in the class. Before she could turn around her gear was put together and on her back and she was in the water. You have to spot this in your classes because it still happens today, particularly I see it often with husband/wife teams, or the female student that is taking the class because of her boyfriend who just happens to be coming to every single class and is putting her gear together. This is what I'm talking about when I say screening throughout the course. Look for measurable performance objec-

tives. Don't just assume that Sally is doing a good job. Is Sally really swimming four laps? Is Sally putting her gear together?

I think, for me, it's okay if the woman is taking the course because her husband or her boyfriend wants her to learn how to dive. That's okay with me if, during the course, she develops some of her own reasons for diving. I see this a lot of times. I see them come in and they're scared, they really don't want to be there and I take them aside and I say, "Hey, look. This isn't going to be such a bad thing and you're going to find that you really enjoy diving. And if you don't, it's okay. You don't have to go diving." I let people know that scuba diving is not a sport for everybody. It's just plain and simple not for everyone. There are some people that do not want to go under the water. And that's fine. That's okay. They can go bicycle riding or play tennis. But if women can develop their own desires during the course, that's good.

If they don't, at the end of the course you might want to do some one-on-one consultation with them because somebody that's diving for somebody else isn't a safe diver in the water. And if that nonsafe diver, who you certified, goes out on her own the next weekend with her girlfriend, and without the boyfriend or husband she's been diving with throughout the course, panics and drowns in the water, they're going to sue you for failing to adequately train her. They're going to cite the fact that you didn't notice a lot of things. Then her boyfriend/husband is going to be the worst witness against you because he's going to testify that he did everything for her during the course, that you never did anything to help her get trained.

So these are the reasons why this screening needs to go on throughout the course. Things could haunt you later. I know that it's a touchy road. It's a psychological judgment call. How far do you go in breaking up buddy teams, husband/wife buddy teams? It is a fact that the husband/boyfriend buddy is the person they are probably going to dive with most after the course is over. So there are certain benefits in them staying in that buddy team. There is also some benefit in splitting them up during the course. They tend to resist splitting up a lot. It all has to be handled very diplomatically.

Failure to adequately address these questions are the events that cause lawsuits. I'm pointing them out now because if you address them in advance, it will help you later in case you ever get sued. Your notes on the class will be useful in proving your case.

CERTIFICATION STANDARDS

I can only emphasize that there's no reason to deviate from the standards that you're going to be judged by. Always bear that in mind. If you deviate from the standards, and someone gets hurt, those are the standards the jury will judge you by.

DOCUMENTARY EVIDENCE

Very, very, very helpful. I think it's great that the agencies are now starting to put a great emphasis on class attendance, giving four question

exams that take 10 min at the beginning of each class to make sure the students understood what was covered the class before.

Keep your own class notes, particularly on special students. For example, if someone was a weak student and you took steps one, two, three, and four to give them special assistance in the area they were weak in, document it. Documentary evidence is very important. The jury will review what I call the paper trail. Who did what, when, and why. Can you justify why you did what you did. Again, instructor conduct and awareness is all important. Visual contact and sufficient proximity are going to be judged in a lawsuit.

In Baton Rouge we have a lecture; just for the women in the class. We do not spend a full hour-and-half, but about 20 min with the women. I don't think it has to be with the women alone. Guys can stay if they choose to. It gives me the opportunity to talk to some of the women in the class, particularly those I've seen that have a problem with psychological dependence on their male buddy. So it's a time when I've got them alone and maybe I can say some things that I wouldn't say to them in an open class. The agencies are not requiring these lectures. It does show that you have addressed some attention to these issues in your class. And then you have that as documentary evidence that you were aware of the problem and addressed it.

All of the regular factors that you look at in a class you need to take into consideration with a woman, for example, if it's difficult to get on and off the boat, make sure they have the physical ability to get on and off the boat. I know we've been using this boat out of Destin for years in which the ingress and the egress is very difficult. The boat captain doesn't want to change it. You need to make sure that everybody is going to be able to do those things.

If you're in California and you're climbing over rocks, make sure your students are trained to climb over rocks. And if you've got really petite women in the class, try and get some of the 50 cubic ft tanks. There's lots of new gear on the market especially designed for women. They make extra small masks and extra small BCs, so that if that student panics on the surface of the water and drowns, it is not because they had a large BC on and slipped right out of it. We've got a lot of gear out there to assist people that are 5'2" and less in size and that weigh less than 115 pounds. And for a long time we didn't have that. So make those things available in the classes.

Some issues I want to cover for those of you who aren't instructors are on rendering advice and assistance to divers in recreational situations whether you're an instructor or not. You happen to be on the dive boat and you see somebody getting in the water, and you see they're doing some things that are just really wrong. How much duty do you have to go tell them they're doing something wrong? If you do go tell them, then, what kind of liability are you taking on? I know that Louisiana and Florida have what's called Good Samaritan laws which state you are not going to be held liable for anything that you do gratuitously, provided it's not gross negligence.

This is lowering the duty by law, if you're a Good Samaritan they basically lower the duty for you and say, "Just so long as you don't do anything grossly negligent, you're not going to be held liable because society wants to encourage gratuitous help."

These laws emerged out the medical field because doctors were stopping at car accidents to help and then were getting sued. And they said, "Well, wait a minute. We're not going to stop and help anyone who needs care if we get sued for it. State Legislatures enacted Good Samaritan laws which, in my opinion, were a good idea. They also apply to other situations if the law is written broadly. Nonetheless, I don't, as a general rule, get involved with other people on a boat in a recreational situation. I just as soon prefer that they not know I'm an instructor because what happens is you get a flock of six people who want to dive with you. Or if you even tell them you're an advanced diver or you've been diving in this area before, you often have the same result.

INSURANCE

Again, those of you who have insurance, it's invalid if you don't adhere to your certification standards. And the insurance issue is really heating up. Any of you who are PADT instructors are aware of that. The YMCA just got a 90-day insurance policy to cover instructors through June 30th (15 day from the date of this lecture. Ed.).

The insurance market is drying up substantially. Part of the reason why is because people are getting sued. Plaintiffs are receiving substantial personal injury awards because instructors didn't adhere to the standards or because they did something very negligent. The whole insurance question really involves a lot more than negligence, which I don't have time to discuss here.

In conclusion, we're finding out that there really may not be big differences between men and women. This is good. Just be aware that at this seminar we're talking at a very high level. You're going to be judged in a court of law, not by a high level standard but by average standards, and average women will be your students. That's what you're dealing with daily.

So try to address the issues and be sensitive to women's particular needs. Make sure they know how to put their regulator on. Make sure they can pick up that tank and put it on without the assistance of somebody else because they may need to do that someday.

Adhere to those standards. If you leave here with one thing, that would be it, adhere to the standards. I know they're raising the standards in an attempt to try to stop Federal Government intervention. What's happening is instructors and dive shops are saying, "No." They're lowering them back down. You're not adhering to them. You'll pay for it later if an accident occurs. We're going to have some large awards that aren't going to be covered by insurance. Then we really will have the Federal Government come in.

DISCUSSION FOLLOWING PRESENTATION BY MS. INNES

JOHNSTON: I'm Lenny Johnston from the Calypso Dive Shop on the Eastern Shore. I have just one question. You said that the standards had gotten higher and that some instructors and dive shops try to lower them. According to what I've heard which came out of DEMA was that NAUI, and I believe, the NASDS got together last year where they did agree to the standard.

INNES: Yes. But then I believe what happens, Susan--you may know about this--but I believe what came out of that, and what's come down from NAUI are its standards which we use at our NAUI shop. But they're all good. I'm not recommending that those are any better.

But I know one of the things that the dive shops complained about was the dives have to be done over a 2-day period now. And that creates some problems for some people. There was supposed to be standardization in the industry. I don't see that that's happening in practice. Again, this may ba a case of what was decided at a conference. I don't see that happening in real life.

BANGASSER: I think, though, they have to be implemented by September first. (1986, ed).

JOHNSTON: I know in our area, the Maryland area, the dive shops I have already checked out this year, are already implementing the uniform standards.

INNES: That's excellent and that's what they need to do.

McGEEHAN: By the way, in the last letter NAUI said not until we tell you differently, use our standards. I thought it was September 1, but the last letter said wait until you hear from us.

INNES: That's going to be a real problem, too, if somebody gets hurt; because the conference, you said, was in the spring. NAUI is saying--when was this conference you're talking about? DEMA was in January, but they're not implementing the standards until September. If somebody gets hurt between now and September, they knew of the new standards or they were going to implement them. So state-of-the-art is going to be judged as of January.

If somebody gets hurt between now and September, and if it can be proven that if you had adhered to the new standards they would not have been hurt, then you've hot some real liability problems that come in.

BANGASSER: A change of topic. You mentioned that NAUI doesn't require that you talk to women aside. A small amount of information is found in the NAUI which encourages instructors to have some part of a lecture geared towards the problems of women in diving. But one thing that I don't know if we're going to touch upon at all is the concerns that the basic beginning diver has, such as diving during her period. So that would be something that both

you and the students might feel more comfortable talking about, if you talk to them aside.

INNES: Definitely. That's when I get those questions, in fact, you know, the women have been silent on that and then you get them alone and they want to know if a shark is going to eat them. This kind of stuff.

BANGASSER: Right.

McGEEHAN: What about compensation?

INNES: Compensation in what way?

McGEEHAN: I don't get paid because I do volunteer work.

INNES: It makes absolutely no difference in a lawsuit whether you were compensated for your services or not. There's absolutely no difference. Now, it will make a difference under the Good Samaritan theory. But the Good Samaritan theory only covers emergency type situations. It would not cover you doing just like I do--volunteering your time and just getting paid for your out-of-pocket expenses.

THE ROLE OF WOMEN IN COMMERCIAL DIVING

B.K. Key
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I would like to talk about going to diving school and being a commercial diver in the field. Since I taught commercial diving, I had an opportunity to teach a number of women. There were problems that did occur.

Social problems are probably more important than physical problems. The woman's acceptance in the diving field is difficult. You have the jealousy of the other students because the woman, if she is highly skilled, creates jealousy. They want to outdo the girl in the class. If she is less skilled, then they are nagging her because she can't keep up or can't cut the mustard, as they say.

On the other hand, some women deal with this very well. I don't know if it is a difference in the group of guys that happen to be in the class or an individual's way of presenting themselves to the group that makes a difference in how they are accepted. But I have seen a great difference in the acceptance mode.

The physical endurance of the woman I have found hasn't much effect. Women can do all of the skills that the men students can do. Now granted the physical strength isn't as great in a lot of cases, but that doesn't really create a problem.

Some men are frail and not very strong. All commercial divers aren't 6'2" and built like a mule. So if you have two things to carry, usually the larger guy takes the bigger load and the smaller guy takes the smaller load. That is how it worked out in school. We had a 40-ft training tank, and there is always gear that you have to get up to the top and back down, as well as hoses and heavy dive hats.

We dove deep sea gear, the Navy Mark V. This is a large suit. I think they only had a Navy dress number 3, which is built for a 6' male, and that created a few problems in getting a seal because the cuffs usually fit the ladies up around the elbows rather than the wrist. So the rest of the suit bellowed over. It is a constant volume suit, so air gets from the helmet all inside the suit. When the air blows up, you have a spread rigid form. So this was one of the problems the ladies did have. But some of the smaller men did too, so you can't really say that's only a woman's problem.

Here are some comments about some of the other equipment. I started diving in the late sixties, and at that time we didn't have all the beautiful colored suits and different sizes. It was mainly basic black and large. So the equipment had to be modified in a lot of cases, but that didn't really create a problem either, except there are no maternity wetsuits. I am looking for a line to come out in that.

In the field now, you have a whole other set of problems. Getting hired, working, breaking out (going from diving tender to diver. Ed.), going offshore. Getting hired is difficult no matter what sex you are in the field today because there is just not that much work. There are more divers than there are jobs for them. But being a woman doesn't make it any easier. If there are six people in line to be hired, they are probably not going to pick the female. I have often wondered why, and I have asked around and gotten a variety of different responses. They just don't want any trouble. There might be problems. They foresee maybe a problem with the lady getting along with the other divers or going offshore. There is no separate restroom. There is a problem bunking everybody because usually all the divers sleep in a small room, maybe have four upper and lower bunks. They are worried about where the women are going to sleep. Where are they going to dress? Do they eat with them in the same place? Where are they going to shower? Some of this is kind of silly to me, but nevertheless, it does affect women being able to be thrown in a totally male environment.

Then you've also got the jealousy of the other guys' wives. There is a female offshore. Here you are going to be off the oil rig for 6 weeks, you know. There may be some hanky panky. I don't think this is necessarily so, although there have been female divers that married one of their cohorts. The diving companies and the contractors think it is easier to eliminate these problems to begin with. Consequently, all women suffer.

In the chamber, getting dressed and undressed, because many times you come out of the water and have to go directly into a chamber for decompression. Well, you usually change out of your wet suit which would be another potential problem for the women or the men, I don't know. Most women that do have the type of personality it takes to be in the all male dominated field can cope with this. Most divers, female divers in a sports diving situation can cope with this. We are all familiar with no restroom on the boat, what do you do. You find a way to handle it. I don't think it is a reason to keep a women from working.

So there are a lot of prejudices in these separate and equal facilities type things.

Physiological problems we have more or less covered in our other presentations.

ATTITUDINAL PROBLEMS

I think it takes a certain type of woman to want to work in this field. It is not the most glamorous type of profession, but the women that do have the fortitude and desire to go into the field I have found to be very good divers. They are on the whole more conscientious divers. They are very safety conscious. I have hired several women, and several work for my company now. Usually you can depend on the women to get the paperwork done where the guys will put it off or half do it. No job is over until the paperwork is finished. Women handle that a lot better.

They are more safety minded. They have very few accidents. They are more cautious I think in their preplanning. They make sure everything is

right before they make the jump. Then when they are underwater, they are more dexterous and they check out the area around them, where the guys just go gung ho and try to get the job done fast. A woman will more or less pace herself. All the work isn't physical. You don't really have to be able to lift 200 pounds to make a successful dive. There are other ways to get around the strength part.

Many of the jobs require an overhead crane. All you have to do is know how to give crane signals, take up on it, let it down. This doesn't require any great physical strength.

We have air tuggers. If you have a large clamp, you don't have to pick it up by hand to put it around the jacket leg. You have an air tugger, if you know rigging, know how to hook everything up, let topside do the work for you. Instead of carrying a heavy tool down the downline with you, you go down, put a line on it, let your tender or rigger on the barge lower it down to your. There are easier ways to do it.

A lot of the guys pick up on it. Oh, yeah, why didn't I think of that. Then they will start taking these shortcuts. I guess where there is a will, there is a way. If you can't physically muscle something around, there is always another way to get it there.

Commercial diving is not all world travel, high pay, and adventure as I thought when I was lured into it. It is a very physically demanding occupation, and I think it takes a certain type person. I wish we would do iceberg profiles (see paper by Dr. William Morgan) on people to see what kind really will make it and which ones are not very good candidates. There are many factors that influence a person's ability to work under water and be a successful diver, and I really don't think sex has anything to do with it.

DISCUSSION FOLLOWING PRESENTATION BY MS. KEY

INNES: What would you say are the three or four most common characteristics you need most to be a successful commercial diver, male or female?

KEY: Oh, you've got to be a little crazy. I think you have to have a good self image and be mechanically inclined, which is maybe one of the problems some women have because they do not necessarily have aptitude on mechanical things. They just haven't had the training that a lot of men have had throughout their life, but that can be learned. That is no hurdle that can't be overcome.

Mental attitude I think has a lot to do with it. You have to want to get the job done and be willing to do what it takes to accomplish that.

NUNNELEY: Have you perceived any change of attitude since women astronauts became a common thing? I should think all these questions about bunking and toilet arrangements and all this stuff would have been addressed.

KEY: I really haven't. Well, you could hit them with the EEOC.

NUNNELEY: Good luck.

KEY: It doesn't do much good. I don't know if the oil field is just a backwards part of our nation.

NUNNELEY: But pilots are pretty backwards, too.

KEY: I have found a lot of times on the job people try to help you too much. If I've got two women and they've got to unload a truck, they can unload that truck. They can do everything they need to do. Then you have three boat hands following them around, and when they start to pick something up, "Let me help you pick that up." That doesn't help us out any. Their supervisor says, "I've got three guys over here tied up getting these women's truck unloaded." What are we going to do about that? You've got to try to be nice and not put anybody down or hurt their feelings. But then on the other hand, thanks, but no thanks, I can really do it myself.

HARRISON: If there is a glut on the market of commercial divers and there is preferential treatment given to males as far as hiring is concerned, what job opportunities are open to the female commercial diver?

KEY: I have found it is good to specialize. I have taken an ultrasonic course, and I am a level 2 NDT. So inspection work is something that doesn't require a lot of brawn. It is more expertise. When you are able to do a lot of inspection, underwater photography, as well as the other jobs, there still is work.

FIFE: I have saturated several times in the Hydrolab habitat, which I understand is now in the Smithsonian Museum. It is one room, 8' in diameter, and about 16' long. There is no place to hide. When I was getting the dive crews together, three people at a time, I would say, here is this gal who needs to go in this thing. She should saturate. I had more problems with the guys having to back out because their wives wouldn't permit it.

Once we were down there, and I was doing some physiology measurements. I was doing blood pressure or something on the other guy, and there was a girl there behind my back. I said, "Hey, Peggy, are you decent?" She said, "I'm always decent. I'm just naked." That's the attitude I hope we come to.

WACHHOLZ: Bunny, can you tell us a little bit about the company and the kind of jobs that you do?

KEY: Yes, Chris. We do a lot of inshore work because it is difficult to get your foot in the door on large offshore operations. I don't know if this is because I am a woman-owned company or just a small business. But we mainly do inshore.

I have done work on Lake Ontario, and a lot of industrial type diving. Clean cooling tower basins, and working outfalls, where the water comes in and out of the plant that they use for cooling. I haven't done much nuclear diving lately. I don't really miss that, although it was the clearest water I've ever seen. I also do inspection work, as well as search and recovery, and salvage, if I'm lucky enough to find some.

WACHHOLZ: How do you overcome the heat problem when you are doing nuclear diving?

KEY: Short duration. You only stay 10 min and then go into a dip tank. It is a closed suit dive where you don't come in direct contact with the water. So you immerse yourself in cold water until you really start shivering, and then you go into hot water so you have a longer bottom time before you become overheated.

BANGASSER: What is the temperature of the water?

KEY: About 120. They cool it off. I think they get it down to about 110.

NUNNELEY: Do you have symptoms when you come out?

KEY: Just perspiration and a feeling of weakness.

NUNNELEY: Do you have any feel for how much you are able to extend you dive time with the precooling?

KEY: I don't really know. Probably only a few minutes.

NUNNELEY: If you are really out to do it, you would probably be better off with mild prolonged cooling. In other words, you could get more calories out of your body that way than by using very cold water that tends to shock and chill your skin and produce shivering.

KEY: It didn't touch our skin.

NUNNELEY: I don't know what your suit was like. Was it an insulated suit?

KEY: It was rubber.

NUNNELEY: That might also keep the 120 degrees away from you awhile. In other words, a highly insulated suit might. If you could cool yourself long and slowly and then have a highly insulated situation when you go into the hot water, those two things together might prolong the time.

WOMEN IN MILITARY DIVING

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We are the only hard hat diving team that the Coast Guard has which is getting disbanded July 1st. I am the only Coast Guard female on the team but the Navy has about 50 female divers.

I started pleasure diving in '79 and worked my way up to divemaster. I joined the Coast Guard in '80, and I never realized why the military had restrictions on height limits. But after 4 yr I learned a lot about that.

I was going to go in the Navy before I joined the Coast Guard, and when I told them I wanted to be a diver, they laughed and said, "There aren't any females yet. So what makes you think you can do it." At that point, I joined the Coast Guard.

Each station I was at, I assisted with dive classes. The instructors liked that because women in the class gained more confidence with the attitude, "If she can do it, I can, too." They could relate more to me than to the male, macho image.

Talking about male and female relationships with dive partners, I think the male dominance is because of a lack of physical conditioning with the females. It is socially accepted to follow what the guy has to say and whatever he says is fine.

There was a unique case in California where the male was on his back, and the woman was towing him in behind her, and he still ordered her, "Go here, go there, go here."

How I became a stronger diver was I would dive with new people and I didn't really know their qualifications. So it kept me on my toes to make sure I knew what was going on with me, plus them, too. Assisting in classes as well as taking courses to advance my skills helped.

I dove up and down the East Coast and West Coast, as well as the Bahamas, Honduras, and that area. I had cold water, warm water, high vis, low vis, mostly low vis, rocky entrances and boat entries.

After my first 4 yrs in the Coast Guard, I tried looking for a job as a diver, but they are pretty hard to get on the outside world. I decided to stay in and try for the Second Class Dive School. There are some requirements you have to meet before you can even get accepted to the school. You have to go through a special diving physical and strenuous physical fitness test.

All my extra time was dedicated to working out--running, lifting weights, swimming--whatever I could do to prepare for school. I got support

from some of the guys in the team by helping me work out and some would even join in on my aerobics classes, which was hilarious to watch. I also got some negative remarks from a few guys that thought I wouldn't make the school because of its difficulty. The school was very demanding, but with personal goals to achieve and a strong determination, I was able to graduate first in the class.

When I got called to speak at this workshop, I did some research. I called the experimental dive unit in Panama City, Florida. I talked to a doctor there, and she didn't think that there were any problems between male and female as long as they got physical conditioning. Women can do just as well as men. Often the navy believes there are too few women in the field to make research worthwhile.

Next, I called the Naval Medical Research Institute and they use guinea pigs for their experiments. At this time the results of these experiments are not available to me.

I called our dive team and asked them their opinions on diving while menstruating. The only thing they worry about is if you are on medication counterindicated to diving. I have never had any problem with it, so I don't worry about it. Something I do notice, I do get a little short tempered. When I have cramps, I monitor them but usually come up after a dive feeling better.

I talked to a couple of our supervisors about being pregnant. We don't know, they said. Some wouldn't let me dive if I did get pregnant, so I don't think I would tell them if I was.

Most military dive equipment is geared toward the average-size male which causes some discomfort for smaller sizes such as myself at 5' 115 lbs. For example, wearing twin 80 tanks is long on my back and I have a tendency to hit my head while looking up. The MK XII dry suit is long in the arms and legs so I have to tuck and fold them under to fit better. The whole suit weighs 127 lbs and causes some problems while climbing a ladder, so I take one rung at a time while coming up. A personal problem I have is my gums have started receding around my teeth. The dentist said it was caused from the size of the mouthpiece in my regulator. He suggested I should trim the mouthpiece to make it fit. I make adjustments in the gear where I can to make it fit better or work around what I can't alter.

One of the major adjustments I couldn't change was the lack of acceptance from the wives of the team members. I overcame problems of physical strength and adjusted gear to fit better or worked around it, but the lack of acceptance by team members and their wives was the most difficult problem I had to deal with. Being the only woman on the team left me vulnerable to criticism by the wives when on the road and also set me apart from my co-workers because of the type of activities they participated in. On the job, I feel my abilities were tested and retested and my acceptance was a continual challenge, while my male counterparts of the same experience level were accepted more readily. In my observations, it seems any woman entering a male-dominated work field faces the same challenges of acceptance.

So, with all this medical stuff, I feel like I have had more of a hard time being accepted than any medical problems I've had. Those are the easy ones compared to the rest I feel.

Now the dive team is being disbanded and I have one place if the billet is open that I can go. But now I am kind of out of the dive program.

DISCUSSION FOLLOWING PRESENTATION BY MS MOROZ

WACHHOLZ: Why are they disbanding the team? Who is disbanding the team and why?

MOROZ: This came down from--I can't blame Gramm-Rudman, but he started the cuts. It all rolls downhill, right. So they say, "We have these different departments, Department of Transportation, we are going to cut you so much." They say, "Okay, Coast Guard, we are going to cut you so much." It rolls all along down the hill. I think that it is our own fault that we are not well known. We did a job on NASA picking up shuttle pieces, and NASA said, "I didn't know the Coast Guard had a dive team."

In the newspapers, we are called "Navy divers," "Pierce divers," when we were on that vessel, and everything except Coast Guard divers until the last day. So we don't get any word out that we are around.

Another thing, too, is that we are budgeted under oil and pollution spills which we don't do as much of as we do engineering. So when we wrote some letters around we suggested they just move our budget under engineering because we help take lines out of the Coast Guard screws, we change props and everything. So we save the Coast Guard money by being there. Now they are going to have to turn around and hire divers to do this stuff. So it kind of goes in a circle.

BANGASSER: Is there just one team of divers then?

MOROZ: We are the only team of hard hat divers, an actual team to go out and do these different jobs. We have divers on icebreakers and buoy tenders that go down and check some buoys. They are just scuba divers, and their main job is not diving. Their main job may be as an engineer, they work in the engine. Their program is not too well thought of on board, and if the captain doesn't like divers, then it is even worse.

BANGASSER: Were you transported across the country as the need arose for a hard hat dive team, or did you just stay in one spot and handle problems in that area?

MOROZ: We have gone to San Diego to do helicopter operations with them. Say if a Hugo drops in the water, we go in there and we all work together to raise it. It depends on if there are certain jobs that they want done. We have been to Detroit doing chemical spills. If a truck was going down the road near a river, and a barrel fell in the water and they want a diver to

up and down. We go to Portsmouth a lot and work on our vessels, but we have been on the shuttle recovery, we have been to Bradford, Pennsylvania, where they are looking for old oil wells that they covered up by reservoir that they thought were leaking. So we go and try to close those up. So it is wherever we are needed to go.

INNES: Do you feel that the female reaction or the reaction to females that you have gotten on the dive team is throughout the military, or is it just because you are in this subspecialty that women don't usually go into?

MOROZ: Between going to dive school and here they say, "Well, if we have to have a female, yeah, you'll do." But I get the impression that it is a more macho world. I have just gotten certain remarks that you can forgive them for because you consider the sources, but you don't forget them. It hurts overall, because I try not to come out and say, "Well, you screwed up on this."

When I was in Bradford, I was driving a small twin outboard Monarch. I had been driving 41s and 44s for 2 or 3 yrs, and in 3 wks, I had three different people tell me how to drive a boat that I had been driving for 3 yrs. I have had other people jump right in. They don't think that we can handle a job. For example, I was working a crane winch , and I was following somebody's signals, and then all of a sudden one of the guys hollered, "Turn the brake on, turn the brake on." It didn't have anything to do with what I was working. Somebody jumps in and tries to take over, push me out of the way. That causes problems, because if something went wrong and I needed to put the winch down, everything would have been screwed up.

WACHHOLZ: Is it getting any better? When I was there, it seemed to be getting better.

MOROZ: I don't tell everybody all these problems because I am afraid of the feeling, well, it's all in your head, you know. We don't treat anybody else any differently. But I still think they do.

NUNNELEY: That's not just the team though. That's human nature right there. There are the doers, and then there are the people--

MOROZ: Yes, but a lot of times when somebody gets something rolling, well, that sounds good and I'll help. But it was more or less, we'll do it and see what the consequences are.

INNES: How do you think it has changed you personally in the last 3 or 4 yr to have to work in such a hostile environment?

MOROZ: I get the attitude, "If I want it, I'm going to go get it. I don't care what anybody says."

FIFE: That's probably what made you a diver in the first place.

MOROZ: That probably is.

MORGAN: Just a comment. The similarity between the SCBA (self contained breathing apparatus for Firemen, Ed.) and the Scuba appears again, because women were confronted with the very same issues when they first come into the firefighting force. Similar problems relative to relationships with spouses because of men and women living together took place, and the equipment was designed for men. Of course, since the workers in the fire-fighting force are usually unionized, they were able to initiate grievance procedures when protective equipment did not fit. I think, however, that many of the same kinds of problems you have described occur with SCBA. You might be able to approach a large metropolitan fire service and learn how they tackled the problem. In other words, they have dealt with this in the large metropolitan areas with the introduction of women into the fire-fighting force. Many of the very same problems have been present.

INNES: What is the SCBA, the initials you just mentioned?

MORGAN: The device I showed on the screen this morning; the self contained breathing apparatus. For all intents and purposes the same physiological and psychological problems that exist with scuba are present with the SCBA.

But the other point involves the sociology of the issue. Female firefighters were often not accepted in the early days and this actually has led to lawsuits in some cases. That has changed. Firehouses usually have restrooms for men and women today.

INNES: That is true in a lot of professions though. When I started law school there was one women's bathroom in a three-story building. They finally added women's bathrooms. This is funny you should mention it, because it was a major issue when I was in law school. It really was. They had SBA meetings about it, petitions, and the whole nine yards in order to get bathrooms on the second and third floor because if you had three classes in a row on the third floor, you had to go down to go to the bathroom. Eventually it changed.

That is why I was asking you how it had changed you personally because I have gone through that same evolution, and what I do, I am basically in an all male field although the law profession in law schools today you find 25, 35 percent female. But that certainly wasn't true--I mean, the few female attorneys that are 45 or 50 that are practicing, they are real loners. But even in my age group, I am in essentially a male environment, and the people who my profession attracts are aggressive, assertive people because those are the ones who excel.

I found that for a while, I picked up some of the attitude that I notice in you, and I had to make a conscious effort to not become anti-male. I mean, I really did because I noticed that trend in myself for a while, and at a point I had to say, wait a minute, Susan, you are getting prejudiced, you are going to the opposite extreme. It was a real evolution in myself as well as in the men I deal with. You have the same situation, for every bar association you have the barrister wives association.

NUNNELEY: The officer's wives club.

INNES: I think it goes across all fields that you have that problem unless you happen to be in a field that was traditionally female. That would be interesting, Chris, to see what your reactions have been in a field that is traditionally female, to be a male in a field that is traditionally female.

WACHHOLZ: I have since gotten over that. I was the first male student to be accepted at Marquette Nursing School, actually the first guy to go right out of high school into nursing there. They didn't have a locker room for men. I had to go find a men's rest room on another floor. There was hostility from some of the female instructors. To my knowledge, I have yet to meet a male nursing instructor. Some of them felt like here is a field where women have excelled and can excel, and there isn't an intrusion of men, and now they are starting to intrude.

Of course, a lot of the males coming into it, have career goals laid out, otherwise they wouldn't have chosen this field that all their male counterparts scoff at. So there was a little bit of that. It wasn't bad. You get used to being, I know some men find it uncomfortable to be in a room like this and they are the only male. I never feel that way.

KEY: You get used to being outnumbered.

WACHHOLZ: It's not bad. I don't mind it. I don't know, I never had that, not to the extent that they experienced.

CLARK: I want to make a comment. I wonder if you experienced any of the positive benefits of being a female, as I have, in some fields. I think actually when you compete in a field that is primarily men, it makes you work harder and discipline yourself better and watch your behavior better. Even though it is kind of tough getting started because they discourage you, I had a lot of discouragement in many ways, as I mentioned to some people. I wasn't allowed to go on overnight trips at Scripts when I was a student there because they didn't allow women on boats overnight. So I missed all the overnight trips. But once you work as a woman in a man's field, even though they may have a lot of objections in the beginning, if you do your job well, you end up getting more credit for doing the same thing that a man does. They say to you, "Oh, you're so brave going in a cave with sharks and everything." Well, I was there with a bunch of men. No one comments about the bravery of the men.

So in the long run I have gotten more credit for doing some of the things that I don't think I should get credit for just because I am a woman. I wondered if you experienced any of that. Did they give you extra credit, extra admiration for doing something because you are a small woman and you are doing the same thing that big men are doing?

MOROZ: They don't really talk to me about how they feel. I always pick up on the negative. I was bringing out the negative aspects, but there are a lot of positives. I do enjoy working with men a lot because I have been doing it for over 6 yr in the Coast Guard, and I do enjoy it. I do a lot of

weight training, and seeing how a guy pushes, I push harder, too. So it does make me improve more when instead I could get lazy and say, "Well, that's enough for me." It makes me push harder and try to reach higher goals. So I like working with the guys. It is just now and then. It is like one bad apple ruined the whole thing. You can have a perfectly good day, and then, all of a sudden, somebody will say one thing wrong, and it's like the whole day is shot. So there area lot of good things about it.

KEY: Once you prove yourself, then people accept you. At first they are kind of skeptical if you walk on a job, but once you make the dive and do a good job, then it is hooray, hooray, you're great. I guess you do get a few privileges.

MAGALETTA: Eugenie, and all the other women in the room, if you are doing the same job that a group of men are doing, and they single you out for praise, is that not sort of a reverse slap in the face?

NUNNELEY: "I don't think women ought to be doing this, but you are an exception."

MAGALETTA: Yes.

NUNNELEY: Wonderful.

KEY: You are judged differently, too, because if a man makes a mistake under water, oh, he is just having a bad day. If the woman makes a mistake, well, she shouldn't have been there anyway.

DIVING EQUIPMENT AND THE DIVING ACCIDENT NETWORK

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I would like to make a comment about the pregnancy discussion and just say that of all the calls that we receive questions on pregnancy, rate number three on the list. It is a very common question. Probably not more than 2 or 3 days will go by before that question comes up. People want to know if it's safe to dive while pregnant.

And of course, as I have said, we give a very conservative reply. I am somewhat concerned that there is not widespread knowledge about the concerns that we share. There still seems to be a good deal of confusion in the public. As an aside to that, I also am seeing an increase in calls by women who have delivered and want to know if it's safe to dive while breast feeding. There is that much concern that diving is harmful for a variety of reasons. I'm rather surprised by that.

I'm going to make some comments on trends in equipment, in advertising and in marketing, with regard to women in the sport diving industry, and a little bit about DAN's statistics such as they are. I'm afraid there aren't many with regard to women in diving. But I have brought some.

I have also brought a new form that we're looking to implement as a diving accident data collection form. And I'm going to talk about these efforts. But as it has been pointed out in some of the earlier discussions, there is a real lack of information on large numbers of divers who have been diving while pregnant, and a variety of other things. We haven't had a good return of information about cases and I hope that this form will enhance our ability to get information on these areas. We'll talk about those problems at the end.

The sport diving industry is rapidly changing. It's a rapidly growing marketplace. There is an estimated doubling of the number of sport divers in this country in the last 5 yrs.

In 1981, the Harvey Research Group was asked by DEMA to do a survey about what some of the problems were in encouraging people to enter the sport and try to rectify those problems to build the business of sport diving. That survey was aimed at instructors. The instructors indicated that 5 to 6 yrs ago, the average diver in the class was a 25-year-old male who was very competitive, and risk oriented. This was the orientation of the sport. But by 1981, a lot of instructors were reporting that often half of their classes were female, and that there was a much wider range of ages in the diving population.

A 1984 survey by *Skindiver Magazine* of 1,600 of their subscribers in which they had nearly 1,500 returns, showed (fairly consistent with other surveys of divers) that roughly 75 to 85 percent of all divers are males. Also in the *Skindiver* survey, it was shown that a large portion of the readers were married and this information is taken into consideration in current marketing.

There is a real concerted effort--and most of the diving equipment manufacturers would readily admit this--to increase the number of women entering the sport. Diving is portrayed in advertisements as something men and women do together. It is now portrayed as a leisure activity, a recreational pursuit for couples instead of a competitive male-dominated sport. These words are key, I think. You're going to see the word "sport" drop from "diving." It's going to be presented as "recreational" in nature, as a leisure activity. They're trying to diminish the perception of risk, of competition, and of danger.

Advertising also shows men and women together very frequently. There's a subliminal message here that says, "Diving is a good way to stay together if you dive together." And it's a good way to meet members of the opposite sex. Go diving, the advertising says, and you will not be alone.

There is also an effort to glamorize women in sports diving advertising. This slide comes from a cable television program called "Scuba World," where the models always wear makeup. And, of course, it is very overdone for the cameras. But there has been talk about marketing waterproof makeup to glamorize the sport as if to say that scuba diving is just as glamorous as dressing for the evening or going out on the ski slopes.

Here is where I think the real impact of equipment developments for women are. It is in the work fashion. I was asked to look at some of the new equipment at DEMA while I was there. And in an effort to bring more women in sports, just like the success that has been enjoyed in the ski industry by implementing fashion changes, so does the scuba industry want to copy that.

The developments in fashion in colors are actually made to attract more women to the sport. You see a variety of colors, different colors in wet suits, on masks, just about any color you could think of, in snorkels. Just about any possible color that you could want, you can have. The hot colors this year are pink and purple. You will see pink masks and snorkels. But not only masks and snorkels, but tanks. I've seen pink tanks, as well as pink stripes on wet suits and BCs. All of this, too, can be color coordinated. You can have yellow boots, fins, or wet suits. You can have pink stripes. Pink is very much there. You know, it makes you laugh, but really, why not? There are lots of people who like this. I have a friend who is color coordinated right down to her nails and fingers. And that's the way she wants it, so why not?

Now naturally, the diving equipment industry is very much behind these fashion changes because they can sell new gear, maybe as often as the fashions and clothes change and dictate new wardrobes. Now, obviously men

also enjoy looking good and being fashionable. But it really has been, from the comments that I have gathered from equipment manufacturers, from women customers, and preference and analysis of the success of the ski fashion industry that has resulted in the changes from your basic blacks and blues to multi-colored designs that you see today.

There are some more practical changes as well, as in stainless steel tanks and lighter, smaller gear. On a population basis, there are more women who are smaller and lighter weight than men. Of course, these equipment changes in smaller designs are useful and desirable by smaller males as well. But as a whole, the industry is looking towards bringing more women into it and selling gear to them.

There's a greater use of plastics, a greater design change to make things more comfortable. Heavy uncomfortable equipment has been the complaint in surveys of both sexes as to why people do not take up the sport and why they do not continue. As the equipment industry develops more design changes, there will be more plastics and much less metal as we've seen already.

There's also women advertised wearing drysuits. Drysuits were portrayed as something mostly for men because of the associations with commercial diving, and with cold and uncomfortable environments. But that's being turned around. They're being presented as more comfortable and warmer than wetsuits and something that's easier and makes the sport more enjoyable for men and for women.

I'd like to talk now about some of our statistics. We looked at a summary of statistics that we reported, of course, for both sexes, between 1981 and 1984. And a couple of significant things that I would like first of all to point out is the total number of calls we have received. The number of calls is doubling at least every year. This past year, 1985, I am certain that we had over 3,000 calls. And that shows that we are, as a hotline organization, much more visible and are being used.

The number of emergency calls by divers, those that reflect accidents or possible accidents appear to be fairly stable. Unfortunately the number of caseworks collected, for a variety of reasons, is much lower than the number of actual emergency cases that we answered. We also must consider the outcome of treatments. The fact that we do not have complete 100 percent relief after initial treatment I think reflects the fact that the people who commonly call DAN are not as often the acute, seriously injured diver, but actually the man who goes diving on Sunday or Saturday might have some symptoms late that evening, goes to work on Monday and may call us Monday or even Tuesday, on his lunch hour with a complaint of numbness or pain that persists. And I think that these long delays are what's accounting for the slowness of their response.

I have some statistics from our files on differences between men and women. But just as a comparison, statistics from Kizer from his treatment records of divers in Hawaii, show that there are more men treated, far more men than in the population that broke out in the earlier surveys, roughly 85

and 15 percent. In ours, however, it's not quite that small. And in the earlier years, from 1981, there was a higher proportion of embolisms among females than among males. We see this again later on. The sex for all cases is very close to the percentages that were related in surveys of the populations of divers, roughly 85 and 15 percent.

In looking at diagnosis by tests, again, there is a higher proportion of embolisms in females to males, and more serious types of decompression sickness in females than the nonserious types. However, the samples are small. I realize that larger numbers are much more desired.

In 1984, looking at all cases of decompression problems there were 149 males versus 35 females. However, it seems that there are larger numbers, again, of serious types of decompression sickness, Type II among females. I wonder if this does not reflect a change due to the increasing numbers of women in the sport today compared to only 5 yrs ago. Does this mean that some of the earlier embolisms and pulmonary barotrauma cases were a result of less experience in the population overall? And does the increase in Type II more recently, indicate that now that there's an older, more experienced population of female divers, or that they are now engaging in diving activities that perhaps are more risky, or whether they're diving deeper or diving longer than they had only a few years ago? I don't know. I think that we need to collect more statistics to settle that.

I am, in my own experience, getting more reports of women who are diving deeper, diving longer, doing much more strenuous types of diving in wrecks and in caves, and being right along with the men where I did not see that only a couple of years ago.

I'd like to now look at an estimate, or a guesstimate, of what the incidents of diving injury in sport divers overall might be. A compilation of numbers of air embolisms and decompression sickness cases that were reported to the Northeast Region of DAN, which is the University of Maryland in Baltimore, shows roughly about 100 air embolisms a year, and roughly 400 or so cases of decompression sickness. The average is about 517 per year total cases. Their survey returns have been anywhere between 50 and 80 percent a year. The figure was 80 percent for 1985 which is a very good return considering that this is a multi-page form, and very complex to fill out. So it's remarkable that they did get that much.

I am currently conducting my own survey, a one-page, very simple survey of all the chambers in the country, in Canada and the Caribbean, asking four basic questions. 1. How many divers have you treated? 2. How many were DCS? 3. How many were AGE? 4. How many could not be distinguished between DSC and AGE? I'm going to follow up on every chamber with enough phone calls to get 90 percent or better so that I'll have a better handle on how many diving accident cases there are. Of course, the survey, as it is, doesn't separate men and women. But the statistics that are available are so scant. This is the beginning.

In my phone calls and conversations with chambers in the Caribbean, I estimate that there are about 100 cases a year, probably a bit more than

that. If you want to break it out by locations, Mexico, Central America would have about 50; Jamaica, half a dozen; the U.S. Virgin Islands, maybe 20, for all the Virgin Islands: Puerto Rico, 20 to 25; and Bonaire, 3 to 5 every year.

This is fairly consistent for the last couple of years. But I'm going to make a more consistent survey in the Caribbean this spring. This adds up to a total of about 617 average number of cases in the area of North America where American sport divers dive. According to estimates by the Diving Equipment Manufacturers Association which, of course, are biased, but it is a published figure, there are approximately 2.3 million sport divers. It varies between 1.5 million and 3 million sport divers actively diving. They make no estimate about exactly what "actively diving" means. They say, "Well, at least once a year."

According to John McAniffe at Rhode Island, in his estimates of the number of people, he would say that someone would have to dive at least 3 times a year to be considered an active diver.

Now, in the *Skindiver* survey in the Harvey Report, the lowest average number of dive days reported was 8.2 and 8.7, respectively; an average of 8 per year. In the survey, it also asked questions about how many trips you took, and how many days diving. Those were separate questions and those ranged up to 15 dive days per year. The most conservative number in those surveys was eight. So, for my purpose, I'm going to use eight dives per year and multiply that times 2.3 million, and it comes out to 18.4 million dives made a year. And multiply 2.3 million divers times NUADC's 3 number of dives per year, and you get 7.5 million dives per year.

The number is probably a lot higher than that when you consider that in 1982, 150,000 scuba tanks were filled on the island of Grand Cayman alone. And our estimate in Bonaire in 1983, were that there were roughly 70,000 scuba tanks filled. So it's not hard to believe that there are many more dives being conducted than this among sport divers.

If you divide these by 617, the range of incidents of a recompressible injury per dive ranged between 0.003 and 0.008 percent. Very, very low. And this is much, much lower than estimates that have been reported elsewhere, certainly, in commercial diving and in chamber dives. But divers are diving shallower, they're using much less bottom times than many of us would believe from the reports of people who come to our chambers with problems. Those people are a small minority of the people who are actually diving.

Now how does this compare, let's say, with the Navy? Well, Dick Vann reported at Long Beach in 1984 that there were 22 cases of decompression sickness between these years in 242,778 no-decompression-stop dives. This actually works out to 0.008 percent. And, of course, these are much shallower dives, discovering the bottoms of corals, and so forth. But I think in the survey among scuba instructors, the incidents among males is nearly 0.008 percent, also. So it is a fairly low risk statistically. But, of course, as we all know the results of decompression sickness can be devastating.

We have tried to collect some statistics at DAN on a national basis and it's very difficult for a variety of reasons. In taking some notes out of a table or statistics, we had 2,000 calls, 290 were emergency calls in 1984, but only 196 case reports were collected. And the quality of those reports varied greatly from just scribbled notes to xerox copies of medical summaries to a few, less than 50 percent, actually completed DAN accident dive data forms.

I've looked at why this is happening and the reason is because there just are too many things going on in a busy life with a diving physician or a treating facility when a diver shows up at their door, to complete yet another form, or to complete another form that comes in the mail from us, 2 or 3 days following, even weeks after the dive accident. It just does not get appropriate attention. And you cannot blame these people for it. The mail is ineffective. What we've decided to do is not rely on the mail, or rely on people's good will to return the surveys. But to use the telephone.

I have a new form composed of three sections. The initial section is a telephone contact sheet for our physicians to use. Our people are awakened in the middle of the night, or they're called out of surgery to deal with a problem. They deal with it as fast as they can and they want it done with. They have to go on to other work. Even they sometimes do not collect all the data that they ought to for a complete epidemiological survey. All that we're going to require of them is to give us the name, address, and phone number of the patient and the place the diver was sent to, and a preliminary diagnosis of decompression sickness, or whatever. That's all they will have to report to us.

That will be turned over to us. I am trying to hire some staff which will do nothing but follow up on these people who contact us with emergency problems. Our staff then will call the facility that the person is referred to an find out what really happened.

So often things change dramatically from the initial call. For example, the person didn't really have the bends, or they didn't really go to the place that our physician sent them to originally. They went somewhere else. And the whole story changes. All the details about the incident change completely. This is why follow up by telephone with the person who was injured and the person who did the treating, I feel, is the only way to achieve a consistent high rate of return of data.

Some of the things that we want to look at is the effectiveness of first aid in the field by laypersons and health care workers. Did the diver get oxygen? When did the diver get it after the dive? How long or what type of delivery system was used? Was it a demand valve giving 100 percent or was it a freeflow that is commonly sold which probably is only giving 35 percent oxygen? And, of course, what kind of symptoms were presented? When did the symptoms start? How did the change? Did the person have spontaneous relief before they got to a chamber or following first aid? Is there any benefit from adjunctive treatment like intravenous fluids, drugs, anticoagulants, or surface oxygen? That is the benefit of a multiplaced treatment versus a monoplaced; or extending a Table 6 or 6A or not extending

it? There are some treatment facilities that rarely extend these treatment tables because of their treatment schedules of other patients. It's economics of time that often dictates what kind of treatment somebody gets.

In this form, I have not included very much information about some of the concerns that women have such as risks of diving during the menstrual cycle, or diving during pregnancy, and of using birth control pills. After having come here, I intend to include those. There are, of course, space and time limitations. You cannot address every medical problem that somebody might have. The purpose is to tabulate some numbers of some of the concerns that we have and be able to present them and publish them and make it available to decrease the risk for divers and improve treatment methods.

I would like to ask your assistance in reviewing this form by offering other things we should look at or solutions to this problem of data collection. It's a very important part of DAN's mission. Unfortunately, it has been a low-level priority because of the need to acquire adequate funding just to keep the hotline going and servicing the many callers that we have.

That really concludes what I have to say other than to just point out that I would like to have your comments regarding ways to improve our data collection.

DISCUSSION FOLLOWING PRESENTATION BY MR. WACHHOLZ

MAGALETTA: Of the area that you would like to cover, what percentage of that area are you covering now?

WACHHOLZ: Canada, the United States, and the Caribbean because that is where our calls come from and because Americans travel to those areas to dive.

MAGALETTA: What percentage of that do you have now?

WACHHOLZ: We have been getting a response of printed data from roughly 30 percent of the calls that we take. That has increased in the last year because we've had several letters go out asking for old data. And so, right now we have a total of maybe 700 or so case reports. But the quality of them varies greatly from very, very detailed to almost nothing more than where it happened and what the problem was.

MAGALETTA: How much more do you expect to get in the near future or in a future period?

WACHHOLZ: I would like to see better than 70 percent return.

MAGALETTA: Do you think you will get that?

WACHHOLZ: If I can find funds to staff people to make these phone calls, yes.

MAGALETTA: My big question is do you think there's a place in here for a pregnancy study protocol?

WACHHOLZ: I don't think other than, "Were you pregnant or not?" I really don't think so because the book is here and is really related to decompression sickness and other pulmonary barotrauma.

MAGALETTA: The reason I ask is you seem to have the network in place. If we ever get off the ground with what I think is an important study we need that sort of a network. And what are the choices with more funding, or whatever, over several years?

WACHHOLZ: It's all a question of funding. That's what it comes out to. We would love to do that.

BANGASSER: Actually, I just have a question of logistics. Does NAUI and all the agencies send you information on their accident report forms?

WACHHOLZ: No, they do not. All of the agencies collect report forms on accidents and near accidents that occur. And they are not provided to anybody but their insurance companies because of fears that these would be used for political and financial reasons against them or encourage lawsuits, or whatever. So they are not given to us.

However, that's partly been because there was not complete trust in DAN in the beginning, that we would be conscientious in using these statistics. We're talking with them and with the various agencies about that. And I think that will become a reality in time. But we've just been around for 5 yrs, or so, and it has taken that long to build a trust among the various parties.

LANPHIER: If there is a question about pregnancy on your new form, let's say a study does get going, would that be a way of contacting the individuals concerned at some future date?

WACHHOLZ: Well, we're going to add the names and addresses with the data so that we can pull out names and addresses at anytime. And I guess we could then select for pregnancy, we could select for women, and then you could do a full survey later on.

HARRISON: Just a quick thought. Why could you not identify, perhaps, regional UMS members' positions who could follow up on these forms rather than having your staff have to do that.

WACHHOLZ: Well, the problem is that we do have regional people. There are regional coordinators for DAN setup across the country, in Baltimore, Milwaukee, New Orleans, Santa Barbara, and Seattle, which all have regional coordinators. And that is part of their responsibility. But these people are volunteers. They are first responsible for disposition of the casualties. I don't think that realistically I can expect them to do much more than that.

HARRISON: But UMS has a lot of members who might be willing to, on a voluntary basis, assist DAN with this.

WACHHOLZ: I would love to see that. And I just haven't--you know, it's on the list.

HARRISON: I know I would. It seems so simple. And it would be very interesting. So we need to follow up on it. But it seems to me you could utilize them.

WACHHOLZ: Well, I'll tell you one thing. In the past, there has not been widespread support that this information ought to even come to DAN. And that has changed or is changing. It's much more widely held. But a few years ago that was not true.

BANGASSER: How about the island statistics--do they get the same reports you get or do they get more than you get?

WACHHOLZ: They collect and tally statistics. They have a problem in that they're not dealing with the person that was injured. They collect their material from the goodwill coroners and police departments and newspaper clippings, whereas we have the advantage that people are contacting us. And people are going to specific treatment facilities, even if they're calling us. We know where they're being treated. So it's a different story and there are many different problems in collecting data.

WOMEN SCIENTIFIC DIVERS

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I will start off with the film, which is about 15 minutes long. This film was made for ABC television, as part of a series called "American Sportsmen" narrated by Peter Benchley. We wanted to film a large whale shark. To find a whale shark and film it with a TV camera crew is a terrific daily expense. We had only 2 wks to complete the job.

I had been in the Sea of Cortez, the Gulf of California on the west coast of Mexico, several years before when David Boubilet and I were working on the story "The Sharks, Magnificent and Misunderstood" for *National Geographic* (published in 1981). We were very lucky. With the help of an airplane, we spotted six whale sharks and actually dived with four. So we were hoping that we could get something like that on film for ABC.

Fortunately, we found a whale shark and we had two of the best underwater cinematographers, Stan Waterman and Howard Hall. Both filmed our encounter with a huge female whale shark, a startling experience because whale sharks are supposed to stay near the surface. They are plankton feeders. They are harmless. They are the largest sharks, the largest fish known. Scientists have estimated that they get over 40 ft, possibly over 50 ft long, although size estimates are often easy to exaggerate and no large specimen has ever been measured accurately. But we are analyzing some of the frame by frame pictures we have of our earlier encounters and think we have one we can document at over 50 ft long.

This ABC film shows a shark that we think is possibly over 40 ft. As Peter Benchley narrates, this shark is between 25 and 30 ft long. That was his guess then, but when we analyzed the photos, we found it was much larger than that. There is one part in the film, as we go deep, where he says the shark seems to be inviting us, "Let me take you where no man has gone before." I always want to interject there, "What about woman?"

This is also a film about conservation. I would like to go into other aspects of my work using scuba as a tool for marine biological research. I have just come back from diving in the Red Sea, and before that, I was the scientific leader of the first diving expedition to South China. I've been on a sabbatical, out of the country most of the year, traveling a great deal, trying to pack all my field work in before going back to a heavy teaching load again in September.

So with that introduction, I will show this film, on the Whale Shark.

(Film presentation)

Well, you know how things are a bit overdramatized for television! This film was made 2 1/2 yrs ago, but it has not been shown much because of the olympic news. We did have a lot of fun making it.

As you all know, diving looks so easy, but that is one of its dangers. Anybody can dive down to 185 ft holding onto a whale shark, but the experienced diver knows what to do in case anything goes wrong. That is the critical thing. If something goes wrong, you have such a short time, a matter of seconds, to correct it. I feel comfortable with experienced divers like Stan Waterman and Howard Hall. Howard was filming from the front of the shark and Stan from the back. As we went deep, it got darker and darker, but Howard kept running his camera. I wondered why he was still filming. I didn't think there was enough light but as long as he was filming, I thought I had better stay on the shark. Later when we discussed it, he said that he had the same feeling, that as long as I was on the shark, he had better keep filming.

After Stan let go at 170 ft, Howard and I kept going down with the shark. I didn't think we would go that deep because, when I had ridden on whale sharks before they stayed near the surface. In fact, once when I rode a whale shark for 8 min I was all by myself far from the ship, I thought. But the ship had been able to follow me because from time to time the shark surfaced and its dorsal fin stuck out. David Doubilet would then yell, "There's crazy Genie. Follow that fin or she may never come back!"

It was thrilling to ride a whale shark. The first time I was so intrigued because I had never seen a marlin underwater, and I passed by four marlin absolutely still, lined up, just under the surface, and hammerhead sharks swimming slowly. It was a most marvelous ride near the surface. On this deep ride, I didn't look at my depth gauge. It was Howard Hall who kept track. I let go when I felt strange. I understand my own feelings about nitrogen narcosis now. I didn't the first time it hit me at 210 ft many years ago. So I am pretty careful about that.

Some of the scenes were later put together. Actually, when the plane spotted the shark, none of us was ready. We all had to scramble into our wet suits. I don't know why, they reenacted the scene as if we all had a feeling and were sitting on the back of a boat geared up and ready to leap in. I guess it made a nicer transition than if they had caught us on film clumsily rushing to get in the water. But still, that is probably the most exciting dive I have ever had, and I feel very fortunate it was caught on film.

I have just come from Egypt where I am working on sand fishes, fishes that dive head-first into the sand and live under the sand much of the time. I started with garden eels many years ago. We built a blind under water in order to get very close to garden eels. I happened to see a big, round, funny looking frame in a dump in Elat. We covered it with Burlap, rolled it on the sand-bottom, cut out peep holes, and watched the eels come right outside the peepholes. We got a wonderful series of photos used in my first article for the *National Geographic* back in 1972.

I got intrigued with sand fishes because they are not as spectacular as the more familiar coral reef fishes, but they have such intriguing ways of living in the sand and hiding and escaping from their enemies. I discovered a new species of fish that I have named after my son Niki because he was with me on that dive when we caught the first one in the Red Sea. Its scientific name is *Trichonotus nikii*. It had no common name. We are studying it now and we call it Tricky Niki. The males form leks like some birds. Tricky Niki lives in the plankton and massive swarms look like sardines from a distance. But the males can lift up "plumes" on their heads and court the females into groups of individual territories they stake out in the sand. They can dive and disappear into the sand in a flash.

We are also studying the behavior of razorfish. We have been studying one harem (a male with four females) for 3 yrs. Razorfish are usually very shy, and when you get close to them they just dive into the sand and disappear. But one very dominant female in this harem is less afraid than the male and comes to feed from our hands. We call her Gill because she has a black spot on her gill. She lives at 150 ft and is the only razorfish we've met that has ever gotten so tame. She will come up and if you give her a hard boiled egg, she will take the top off neater than I do, and then go in and get down to the yoke. She will actually bury her "razor-sharp" head in the egg while eating all the yoke. Then she will swim around looking into your face mask as if to say, "Do you have another egg or something?" She is really cute!

Other divers do not go to this rare spot at Ras Mohammed in deep water. It is at the bottom of a garden eel colony we are also studying, and where we found another new species this past month, a strange black fish that lives along what we call our "coke line." We have a line down the garden eel colony with a coke bottle at every 10 m.

The first summer we studies "Gill" she started eating out of our hands. She would start to come up to around 110 ft to meet us when we went down. Now she meets us at 70 ft in these clear waters of the South Sinai. Each razorfish knows its territory. The male has specific dive spots, and each female has a subterritory with dive sites within the male's territory. Somebody said I should stop describing harems the way I used to. A harem may not really be where a male has a territory with females inside, but rather a group of females that have territories and have a male to do the work of protecting the area while they go about the business of reproducing.

We have seen razorfish mating. In each harem that we studied, the male usually mates with each of the females in turn every day at dusk. Bottom time is important. When we first started studying the zonation of razorfish, we studied the species that live in shallow water from 3 to 20 ft; and another species from 20 down to 40 ft, and another at 40 down to 80 ft. We are now studying the toughest one, the deepest-water razorfish. "Gill" is part of a harem in 110 to 150 ft, and that means that we have less time to observe this group. As you saw on that whale shark dive, we didn't make a decompression stop. The ride was probably a little under 5 min; we were safe enough. But with deep water razorfish, we have to make decompression dives.

Let me add one more thing about a razorfish. They are what are called protogynous hermaphrodites. (Proto, first; gynour, like gynocologist, or first a woman). All these females in the harem have the potential for turning into a male. If anything happens to the male, the most dominant female, like Gill, can take over as the male. They can switch sex. They change behavior in a matter of minutes. As soon as the male is gone, the most dominant female starts to act like a male. Within 2 wks, if the male doesn't return, her ovary changes into a testis. Histological studies made by some of my graduate students have proven this.

This is turning out to be a common phenomenon in the sea. Many species of fish are capable of changing their sex, usually from female to male. So if you come back as a razorfish, you will know what it is like to be both a female and a male.

DISCUSSION FOLLOWING PRESENTATION BY DR. CLARK

FIFE: Could I begin the questioning. We have been discussing matters of attraction, sexual attraction, and we have talked about sharks a little bit. I would like to hear your view on the danger of diving with sharks, particularly as related to the female. Have you got any feeling on that?

CLARK: There is one case I know about in Elat where a shark attacked a young woman and who was menstruating at the time. She did a foolish thing which no experienced diver would do. She swam far out from shore, way out into the middle of the upper part of the Gulf of Aqaba into the ships' lane and there encountered a mako shark, which bit her on the arm. A very unfortunate thing then happened. A small boat came out and the people in the boat were going to try to get her in the boat. But then they saw the shark start to attack her again, and they were afraid it would upset the boat, so they rowed away and left her! She was repeatedly attacked on one arm and lost first her hand, and later had to have her arm amputated further up. She eventually died of complications and psychological trauma. Her family sued the township of Elat for advertising that their sharks weren't dangerous.

She was probably swimming in water over 1500 ft deep, and where they dump garbage off ships. Sharks can be conditioned and can associate such areas with food. I think if she had been swimming closer to shore and a mako came along, it wouldn't have bothered her.

For the average swimmer or diver I don't really feel that there is any significant danger from sharks. I have never encountered any. I think the danger is in what you do in the water. If you want to observe a big hammerhead or try to get in the path of a school of hammerheads coming along as we have done quite often in the Sea of Cortez, just sink to the bottom and sort of blend in with the rocks and corals, and as the shark starts to approach, hold your breath so your bubbles won't frighten them away, and they often will come within a few feet of you as they pass by. But if you blow bubbles or you start to swim around or swim after them, they will all turn and go away. If you do something foolish like spear fish, or swim far

from shore and make splashing sounds that seem to cue in sharks the most. Irregular low frequency vibrations in the water invite trouble. That is the vibration a struggling fish would make. You could have a whole school of tarpon swimming around, and you will have hammerhead sharks swimming with them as we have seen off the coast of Florida. Nobody bothers anybody. But once a tarpon is hooked and it starts to struggle on the hook as it is being pulled toward the boat, as we watched hammerhead sharks, they went right toward the struggling tarpon. That is their cue for easy food. So if you do something in the water that makes a shark feel the dinner bell is ringing, then you are in trouble.

I think the experienced diver knows how to avoid these situations. In fact, Jack McKinney, for example, once saw an unusually big shark in the water and he started photographing it. It came up close, and he finally pushed it away after it got very close, and he took all this footage of it. Later he found out it was a white shark.

When we dive with white sharks chummed in with bait, as the lady in the back of the room has just come back from doing in South Australia, we get in cages. Some divers have gotten out of the cages for brief times. But this is risky business when Rodney Fox is pouring chum into the water, bait and oil, and minced tuna meat, and horsemeat is hanging all around the boat. It is foolish then to go out of a cage with a white shark around. But even a white shark, that has been defined as the ultimate predator, probably is not dangerous to swim with if you are not setting up any of the cues to make it think that their usual food is around, such as paddling a surfboard and looking like an awkward sealion in silhouette up at the surface.

I think there is an explanation for all the shark attacks if one could study the circumstances carefully enough. There are those few rare cases where we don't know all the circumstances, and it appears as if the shark attacked without any provocation. I think those few cases are not worth worrying about. It should be of more concern, to buckle up your seat belt on the way to the beach where you are going to swim or dive. Your chances of being killed are a thousand times greater driving to the beach than it is to go into the water and dive with sharks.

HARRISON: Could you mention just a little bit about how diving was in China?

CLARK: Yes. I think we were the first foreign diving expedition to go to south China. We went to the small coral islands off southern Hainan which is the most southern big island in China. It is just slightly smaller than Taiwan. It has coral reefs and palm trees, not the way you think of China. Hainan is the vacation spot for the rich Chinese that live up north. Now China is developing tourism.

So we got great cooperation from the Chinese government. We had a retired head of tourism is South China escort us on the whole trip and was the translator. We had the famous writer, Jade Snow Wong, as the second translator and organizer of the trip. I was the scientific leader. We explored reefs off Hainan which were fascinating.

But since Hainan is a big island and has rivers with runoff, the water had only about 50-ft visibility. So we didn't see as much as we hoped. We never saw a shark, for example. I am spoiled I guess by the north Red Sea and diving in water with 150-200 ft visibility. So from that aspect it was a little disappointing.

But we are hoping to go back in 2 yrs because there is another set of islands, the Shisha Islands, way out in the south China Sea. They are little coral reefs, known mostly to fishermen. But the kinds of things we divers might see, such as some of the small tilefish and razorfish, are seldom caught by fishermen. There is a whole rich fauna to be explored there.

We did catch one unusual nudibranch to deposit in a museum. It may be a new species. But we brought back nothing else from the sea. It was terrible to find in south China that as you got near the beautiful coral reef areas, there are dozens of little stands, like hot dog stands, and stores selling massive amounts of corals that have been taken from the reefs and made into souvenirs. You know that is the beginning of a very sad destruction of the reefs. We are writing to the Chinese government to try to stop the taking of shells and corals. In this beautiful tropical area where they are just starting to develop tourism, it is like killing the goose that lays the golden egg. They are destroying the rich habitat of fishes and other marine life.

But it was a fascinating adventure. We had the cooperation of the Chinese Navy. It was a wonderful place. I think if the Shisha Islands open up, it will be an outstanding place to go and dive if they properly protect it. But as you know, so many of the beautiful reefs, like the ones at Hurgada off the coast of Egypt, have been simply ruined by fishermen dynamiting, spear fishing, oil pollution, and destruction of coral reefs for souvenirs. We are working in an area at Ras Mohammed that we have lobbied to get the Egyptian Parliament to protect. They finally passed a bill and made Ras Mohammed the first national park of Egypt. It is the first time any country has made a marine park their first national park, but Egypt did that a few years ago. I had the good fortune to talk with President Mobarak about the development of this park and its management. He is very much interested in developing the south Sinai. It could be a great tourist attraction if they don't ruin these magnificent coral reefs.

This area is already being damaged. Beer cans and bottles are thrown off boats onto the reefs. Monofilament fishing lines are strangling the corals. Fishing, shelling and taking coral is no longer allowed, but there is not enough enforcement of the laws. However, many good Egyptians are working on this problem and the Egyptian government has asked me to be on an advisory committee.

The Multinational Force and Observers, the huge peacekeeping camp in South Sinai, is a wonderful base composed of more than 2000 people beautifully organized. I give lectures there to the American troops. But there's not much recreation there. To some it's like the end of the world. But for swimmers, they can take advantage of this unique area. They have diving

instruction. For those who take up scuba diving (about two-thirds of the men stationed there) their 6-mo. stay is a delightful experience. Many want to come back to dive more on these gorgeous reefs. This past April, the new park manager and I organized a Ras Mohammed underwater cleanup and we got some of these healthy strong men to come down in their scuba gear and help clean up. We took big plastic garbage bags and filled them with debris and we unwound the monofiliament line. They plan to continue this every month until they get this marine park in good shape. So this is another diving project in which I am involved.

There is another project, which is very exciting because last week we just found out we had finances for it. As you know, it is sometimes difficult to get research grants. I didn't really think this project would come through because of the enormous expenses involved--more than $300,000. But while I was in China and Egypt, Emory Kristof, deep sea photographer of the *National Geographic*, Joe MacInnic from Canada, Peter Benchley, Teddy Tucker and a few others worked on what we call the Beebe Project. We are going to study deep-sea sharks off the coast of Bermuda. I am leaving June 15th for this research adventure. It is the first time since William Beebe (50 yrs ago) that we plan to explore the deep sea to study deep-sea creatures.

We have the Pisces VI, a deep diving submersible. We will start at 1000 or 2000 ft, but the Pisces VI can go down to 8300 ft. So we have that project underway, and it is very exciting to start. I guess in my old age I am going to be comfortable inside a submarine instead of diving. Not really. I am going back to diving on another project right after that.

That updates my current projects.

FIFE: Would you care to comment on the equipment as you found it for female divers? Any problems that you have run into?

CLARK: There are no real problems. I have a slight back problem, maybe from showing off how I could carry two tanks at a time when I was young. I started hard-hat diving before scuba, back in the 1940s. Then when scuba came in, of course, there was much more freedom. I hardly ever do hard-hat diving any more. We were tethered to the boat and with a compressor up on the boat pushing air down to you.

But I found that the equipment is a bit heavy for me, and I wish they would make smaller equipment for women because women use less air. I sometimes use a little pony tank. If I go out with the usual group of divers a pony tank will do for me. For an ordinary 30-45 min dive in less than 50 ft, I don't need a big tank, and I find the other equipment cumbersome.

I am hoping to get one of those little Techna mouthpieces. Like my daughter, who is a pilot for Continental Airlines, I find the equipment for my favorite activity is still mainly made for men. Of course, the wet suits, and the matching pink flippers, masks and snorkels that they are

putting out for women, especially in Japan, are more than adequate. But the basic equipment is still hard for those of us under 5'4".

UIHLEIN: Would you comment just briefly on what advances they have made in shark repellents, or what you can dress in and not dress in?

CLARK: Shark repellents or deterrents can be divided into a number of categories: physical, chemical, netting, just to reduce shark population. For actual encounters with a shark, there are electrical and other devices that can sometimes be more harmful to the person using it than the shark would ever be to that person. For a long time there was not a chemical known that was really effective against sharks until we stumbled on the Moses sole in the Red Sea, that has a very effective chemical which it slowly secretes and covers the sole's body. The chemical is not shot into the water. It stays in the mucous coating of the sole's body and only needs minute amounts, to prevent a shark from biting it. If you wipe that mucous off, the shark will swallow this little sole. I have published results to show that in our tests the Moses Sole secretion is 100 percent effective in keeping a shark from biting it. A long chain protein molecule is involved in this secretion, that is not heat stable. To synthesize it, in a heat stable form, would be very difficult. That hasn't been done yet, although the molecule has been analyzed by toxicologists and biochemists. It has been found by Dr. Eli Zlotkin, an Israeli toxicologist, that this molecule is closely related in structure to some detergents.

Dr. Samuel Gruber has published a paper concluding that a detergent he tested is even more effective than the Mose sole toxin. But he did not take into account that he compared the detergent with the lyophilized Moses sole toxin which is only one-seventh as strong as the fresh toxin as it comes out of the Moses sole. So the Moses sole toxin is still the most powerful chemical shark repellant known.

They are trying various ways to use a detergent. We tested a "bubble suit" made with plastic bubbles that you use to pack things in cases and are fun to pop. Wearing a suit with these bubbles of detergent all over may deter a shark if it tries to bite you. Its teeth would prick the bubbles open and the detergent would supposedly send him away. But Rodney Fox didn't want us to chase the white sharks away because he was running a tour in which people wanted to get in the water in cages and see the white sharks. So we made only one test that seemed to discourage the white shark for a while. All of these tests are mainly for psychological reasons. So many people still have this terrible fear about sharks, and they think if they are in the water and they see a shark, the shark is going to attack them. If they know how slim those chances were, they wouldn't worry so much. But for psychological comfort, it may be nice to know that you have some kind of a shark repellent with you.

When we first found this chemical, the Coppertone people, the vice president, called me and said, "We have a new suntan lotion that doesn't come off when you go in the water." They wanted to sponsor research on this chemical because they would like to sell a tube of lotion that would prevent both sunburn and shark attack. Such a product might become a psychological

crutch or fad. What are your chances of having that lotion on, in that one in a billion chance that a shark would attack you?

There are four species of shark repellent soles. Two live in Australia, one in Japan, and one in the Red Sea. I studied the one in the Red Sea, the one in Japan, and one in Australia, and found that all have the ability to repel and kill fishes.

In Japan, we set up glass beakers in which we put different kinds of fishes. Then we added measured small amounts of the secretion from the Japanese toxic sole. I used an airstone to keep enough oxygen in the water, and the bubbles for the airstone churned up the water surface like soap suds. I had to brush the suds off to see the test fish, its respiration rate and when it died.

In rare cases where you are attracting a shark, such as Valerie Taylor does, when making a film about sharks, maybe it would be well to have something to deter the shark from biting vulnerable parts of your body. You probably saw that dramatic film of Valerie trying to get one of 40 blue sharks in the open sea to bite her when she was wearing a protective, heavy, chainmail suit. She had to lure the sharks in with hand held fish. Then just as one opened its mouth to bite the fish, because she couldn't get it to bite her, she stuck her elbow in its mouth. If finally bit her showing how difficult it is to get a shark to bite you even when it is stimulated from the smell. The shark then bit and inadequately protected part of Valeries's body. Such experiments are not scientific tests. You wouldn't really test a chainmail suit by putting a person inside it the first time. But it is dramatic for television, and Valerie and Ron Taylor make their living as excellent photographers with some fantastic footage of sharks. I thought this footage would show how difficult it is to get a shark to bite you, even with all the fish in the water. But it doesn't come across that way because people still want to think that sharks are killers. They say, "Did you see the way the shark attacked Valerie?" How could they miss how difficult it was to get that shark to start biting her.

Actually, any hard object will deter a shark. The only time a shark slightly attacked me was when a big shark came up to me, and I had my hands full of things I was using in an experiment underwater. I was diving in the clear blue Red Sea off Sudan from the Calypso with the Cousteau crew, and the ship's doctor was my buddy. We were over deep water at about 80 ft. I saw this shark coming right toward me, not on a scent cue but straight in a visual cue. I didn't want to let go of my things. So I pointed to the shark coming in. My buddy was carrying one of these shark billies that the Calypso crew used at that time. As the shark came in, we huddled together, our backs against the reef, as he hit this shark on the nose. The shark just spun around and went away. Anything like that will deter a shark: a camera, a clipboard, as in the case of my graduate student, Anita George. When a large shark came toward her she took the clipboard on which she was writing notes and pushed it against the shark's nose, and turned it away. I think that is the practical thing to do. Use your hands if you have nothing else but you might get scratched and start bleeding. A hard object is best.

We had a shark fast-reload bang stick given to us for protection against sharks. You insert little bullets and you shoot the shark. It is really one of the most effective shark deterrents, because you just have to give the shark a sharp poke with it in any part of its body, and it effectively blows up the shark and stops it dead in its track. It is the most effective mechanical shark repellent known that a diver can carry.

Rhett warned me, when he learned we were going into caves with big sleeping sharks in Mexico, that this is a very dangerous situation. He said, "Hit the shark with the bang stick if it starts to come towards you, but be sure to face the stick, and have your nose aligned with the stick, because if you turn you head you might break you eardrum when the bullet fires."

Well, we were more afraid of breaking our eardrums than we were of the sharks, because the sharks turned out to be in a dazed condition, and we didn't feel at all afraid of them. One that "woke up" from its sleep was an eight footer that was brushed aside with the clipboard.

So we never put bullets in the bang stick. We used it to poke the shark once when Roman Bravo, the great Mexican cinematographer was filming and needed a little action. Then we marked off the nice steel stick with 10 cm lines, to measure the size of the caves and the sharks. So when Rhett came out with his new superbang stick, he sent me one with a note, "Here is a new measuring stick for you."

SUMMARY

It is now time to summarize the information which we have covered over the course of the presentations and discussions, and if possible to focus our attention. I have listed six items that to me summarize some of the things brought up during the workshop. I would like to present these and then ask all of us to consider each in turn and add, delete, or reorder into a final list, reflecting what we feel is a sort of priority order based on their relative importance to the field of women in diving.

First, it seems to me that we still have not settled the question of pregnancy and the fetus. Therefore, I think that perhaps it is one area that may need some additional research. It would be nice if this could be done on humans, and probably the only way we can do that is by a questionnaire.

Next is female susceptibility to decompression sickness. Is it possible that the woman is indeed no more susceptibly to decompression sickness than is the male? I suggest we ought to look at that some more.

The next is some definitive work on shark attraction. The only way I think that that is going to be put to bed is to do a very careful study, perhaps under carefully controlled conditions in the laboratory. And I don't know that even that will answer the question. It is certainly not going to answer the question of the aggressiveness of the person who might bring on an attack, but it may be able to add something to the chemical and perhaps the pheromone question if that is involved.

The next is the body composition of women. It seemed quite clear from one of the discussions that we really are using a formula for the body composition that may not be applicable to women. Is it important enough to try to have something done there?

The next is the study on pregnancy outcome of divers. Again, that may refer back to the first question. Perhaps that also is a questionnaire type of thing.

I was very fascinated with our recent discussion about the possibility of women having lower oxygen consumption all other things being equal. I would like to raise that again and see if anybody has some other ideas or would like to comment on it.

HONG: Would you add one more item to this list? There is a myth in physiology regarding the difference in thermal responses between females and males. One myth is that the difference in body fat or subcutaneous fat is responsible for the different thermal responses to cold between the female and the male. My question is, is it? We have to detach the role of body fat and study the differences in responses to cold between males and females. There are no good studies which provide answers to this question.

NUNNELEY: You mean thin females versus thin males and then fat of each?

HONG: That's right. In all studies, body fat content of female subjects is twice greater than male, no matter which paper you look at. So we have to detach this component, otherwise we will never be able to ascertain the true gender difference. I think somebody has to do a good experiment, good studies on this.

BANGASSER: I just want to support the fact that I believe there should be something done on that. After listening to your data on the woman I kept thinking that when I am in the pool with my students at the end of and hour and a half, I and many of the women are shivering, and the guys are comfortable. So it might be the distribution of the fat or something else.

HONG: I think this needs to be done.

FIFE: Do you feel it is necessary to attack the question of being able to measure body fat more adequately? Does it go back to that?

HONG: No. I think Sally is right, that we should work on the subcutaneous fat when the skin is in contact with the cold environment. That is easy enough to measure. But the problem is the selection of subjects. We need to study a group of male and female subjects with comparable subcutaneous fat. Then I think probably we can begin to compare more realistically, independent of the body fat.

FIFE: Does anyone feel that there is a problem with the response to increased heat load? It was mentioned of course that increased heat can have an adverse effect on the fetus, even on the embryo at both ends of the pregnancy cycle. When I was hearing that, I was thinking, "Well hot baths don't seem to bother the Japanese women." Of course, as a matter of fact, you also must consider the male. Although cryptorchism can cause a male to be sterile, the Japanese go into hot baths so hot that you have to apologize when you get in because you disturb the water of the woman or man sitting next to you in the tub. Yet, they don't have any pregnancy problem and the males certainly are not sterile. Is there some peculiar thing here?

NUNNELEY: You are talking about a very short duration pulse of hyperthermia.

FIFE: So probably the short duration is safe and that is not a problem.

How would you recommend the matter be studied on the female susceptibility to decompression sickness? For example, do you think it would be ethical to give females decompression sickness, since it certainly was done in males, to develop the tables?

NUNNELEY: They just did it at Brooks. They deliberately took women to simple bends. These were contract personnel. They were simulating NASA space suit activities.

BANGASSER: Can the military, since that is where you get a lot of "volunteers," do something like that, study decompression sickness?

NUNNELEY: You have to convince them that it is in their interest to do so.

FIFE: You really wouldn't have to use military people at all, because a university could contract to do this.

NUNNELEY: I think your best bet would be NASA because they are really worried about female astronauts that have to go outside and work in a suit.

BANGASSER: They would be studying altitude decompression sickness.

NUNNELEY: Yes, but you might interest them in it at the other end of the spectrum, since you are trying to get some basic information. Is there a physiological difference. I think you are more likely to get NASA interested than you are the Navy. The Air Force might go in on it.

MAGALETTA: If you take somebody on a 60-ft, 60-min dive, and they come up with no problems, then if you put a tourniquet around their arm or leg, what are their chances of getting limb bends?

LANPHIER: Very good.

MAGALETTA: But on the other hand, one of the problems is, you don't know how close that person is. Because when the Navy developed these tables, they developed the borderline and then they backed off. You don't really know how far they backed off. So you don't really know how close any of us are to the bends level. Isn't that correct?

LANPHIER: Well, in any given case it is very hard to tell.

MAGALETTA: What if you took a group of women and a group of men, 60-ft, for 60-min, and put a tourniquet on them to see who gets more or quicker limb bends. Is that going to be a dangerous situation?

LANPHIER: Probably not, but I am also wondering what it is going to show.

MAGALETTA: To see if there is any difference in the incidence of bends.

FIFE: I think there are better ways of doing that because what you can do is repeat some of the actual dives that the Navy did when they first developed and tested their tables. You might as well go whole hog and not try to make an artificial limb. My reaction would be that at least. Do you think so?

LANPHIER: I have an awful lot of reservations about deliberately producing decompression sickness in normal people. I think you have to learn anything, and yet, if you had a really serious case which didn't respond readily to treatment, apologies wouldn't be enough.

We think of doing this in medical students, for instance. They are fair game. But it is not a very nice idea.

FIFE: Well, their future earning power is such that instead of having a $200,000 judgment against you they would have a $5 million judgment against you.

INNES: That is assuming they graduate. What about getting people from--commercial divers bend themselves all the time on a routine basis. Can't you hook up with the commercial diving field? All the commercial divers I know, just about all the dives they do offshore, they bend them, they bring them up, they get bent, and they go in a chamber in less than 5 minutes, and they take them back down under pressure and decompress them on treatment tables.

NUNNELEY: That was how they did it at Brooks because the hyperbaric chamber is right there beside the altitude chamber. The answer was, if the symptom didn't resolve on descent, you would pop them right into the other chamber and go on down.

INNES: Am I not right, Bunny? They are bending people all the time offshore.

KEY: Well, they try not to.

FIFE: At one time one diving company was bending 33 percent of its divers, but that is not current. That was a few years ago. Because of the suits, they are a lot more careful about that now.

CLARK: I would like to suggest another area that needs research that isn't the concern of most of you here. That is the older woman diver. Here we are talking about pregnancy and menopausal effects, but those of us who are past those stages are concerned about it. Recently I asked my doctor, since I have some osteoporosis, and one doctor in Japan said I should stop diving to below 100 ft. Then I heard about calcium, so I have started taking calcium, and then I read it wasn't doing any good because my estrogen level was low. So I asked my doctor to give me estrogen. He said no, he wouldn't prescribe a thing like that, but he doesn't know anything about diving.

Diving is one of the few sports and physical activities that you can keep on doing as you become older. Women's problems are different than men because of, a you mentioned, the calcium intake.

I know I dive with women who are over 80, and many who are over 70. Ruth Turner is an example of a deep diving woman who is doing all kinds of things in connection with the Navy, and she is over 70. And a whole bunch of us are over 60. We don't know really how to take care of ourselves because there is not enough research on older women. Should we take calcium? These problems I think should be addressed to a group that is studying women. Because women can continue doing this. We are going to outlive the men probably if statistics keep up.

MAGALETTA: I don't think that is unique to divers. You can have this problem whether you are a diver or not. I think the majority of physicians

feel you are going to benefit from an adequate calcium intake, exercise, and estrogen, after menopause.

CLARK: The question is about osteoporosis in deep diving over 100 ft.

MAGALETTA: I don't know. That is certainly something that would be nice to talk about, but you have the same problems with old men. They also are losing calcium, and they have osteoporosis as well. It just develops at a slower rate.

CLARK: I have spoken to several older women about this problem, and we really have no guidelines as to what to do. Should we exercise or diet differently from younger women or men if we want to keep up our diving?

HARRISON: Eugenie, I work with an osteoporosis center. Every woman beginning at age 35 to 40 should start increasing their calcium intake, and after they become menopausal should consider estrogen if they don't have any contraindications, whether they dive or whether they don't dive. There also are certain genetic traits which tend to predispose females to get osteoporosis.

The ideal way to follow it would be to take women who dive and women who don't dive and do bone densities on them over a serial period of time to see if there is any difference between females who don't dive and those who do, those on calcium, estrogen and so forth. If they could put together that kind of a serial study, it would take some real input, but I think it would be very useful to see if diving does increase the incidence of osteoporosis in the older female.

NUNNELEY: I want to go back to decompression sickness. It seems to me we are looking down the wrong end of the telescope. We keep trying to disprove a study that wasn't very good in the first place. Until you can give me a really good reason why women should be different from men in this respect, I don't want to study women any more to see if they do or don't get decompression sickness. I would rather look at mechanisms. If you can't come up with something about the platelets, the clotting mechanisms, or the circulatory patterns, leave it alone.

WACHHOLZ: I agree with that because there are more and more parts of the public believing that there is, or probably is, an increased decompression sickness risk for females. Well maybe we should study this further. Probably by the time we find out that there isn't any difference between the sexes, the public will believe on a widespread basis that there is.

NUNNELEY: If there isn't a problem, why are we studying it?

WACHHOLZ: Is there any reason why we can't come out with a statement in the papers that results from this conference have led us to doubt that there is a risk?

BANGASSER: I have a couple of comments. First of all, you criticized Bruce Basset's first paper. His second study corrected some of the problems in

the first. If you have access to the Air Force records, maybe you should take another look at those statistics from your point of view.

My study was completely independent and did show an incidence of decompression, and the male statistic was 0.007 percent which correlates closely with yours. However, it is still a survey, and we are still relying on people's answers.

I disagree with the statement that there is probably not a problem with increased decompression sickness, even though so far it hasn't been conclusively proven that there is a problem. I don't think we can say that therefore there isn't a problem. I think the question should be looked at further, whether you look at it through the mechanisms, or through some other way. But I don't think it can be ignored. It is still a question.

NUNNELEY: Could we say something more on the line that there does not appear to be a major problem?

BANGASSER: That I would agree with.

WACHHOLZ: I didn't say we should say there is no problem, just that we should qualify it.

NUNNELEY: I am more worried about an overweight male than I am about your average female.

INNES: Or just looking at the general subject, what I would like to see emphasized, is to really leave the impression on your students that those Navy dive tables were calculated from a profile which doesn't apply to anybody in this classroom, male or female. Unless you happen to be teaching college students and there are some guys in there that are in great physical condition. Other than that, your average class student doesn't meet the profile. So knock 10 min off those tables.

FIFE: Let me see if I can put a slightly different perspective on what I view we really ought to try to do in this workshop. This document that we are going to produce, I would hope, is going to be useful to physicians as well as diving instructors who are going to be having to help people make a decision on their diving activities under all conditions.

Therefore, it seems to me that we should be raising questions that will help them by providing an answer, or raise questions that ought to be further studied. The fact that we might decide to recommend that decompression sickness in women (their susceptibility) be studied doesn't mean that we feel that there is problem. But until the matter is clarified with some experimental evidence of some kind, it is always going to be a question.

You don't help the physician to do anything definitive except to say, well, probably you ought not to dive, or you ought to add time to the tables or whatever. So I would hope that we would try to not limit ourselves to

things that we know are problems, but things about which there is a legitimate question that perhaps can be solved.

WACHHOLZ: Can I ask Sue a question? Do you think that there is enough of a question, and Bill, too, that anybody ought to be saying to women that they ought to be more conservative than men, or just that there is a question that there could be an increased risk requiring further study? Why tell women that they should dive shorter and shallower than men?

BANGASSER: You see, I tell everybody in my class that there are good reasons for everybody in this class to be following the dive tables conservatively. And I include in my lecture the fact that women may be more susceptible.

WACHHOLZ: Do you tell them they should dive shallower and shorter?

BANGASSER: I just say that they should be conservative following the dive tables.

WACHHOLZ: Do you tell the men that they should be conservative--

BANGASSER: Yes.

WACHHOLZ: Or less conservative than women?

BANGASSER: I say to the whole class, that everyone in this class has good reason to be conservative in following the dive tables and stay less time than the time indicated on the dive tables. So I bring up all the "maybes" and "ifs" that might make them more likely to get bent. You were tired, you partied too late, whatever. So everybody in my class leaves the class thinking that they really have to be very careful following the dive tables.

In the meantime, I don't know how we go about getting an answer, but I think that is the issue we should address right now. How would you get an answer? One way might be to look at records from the decompression chambers, and you might have a method to do that.

WACHHOLZ: It is one of my major goals to include data collection for all divers from the chambers that are out there, and I expect that we will have that. We are going to have better data than we have now. I hope that a year or 2 yrs from now I will be able to have a much more accurate report on statistics than I could now.

FIFE: See, one of the problems that you face, Sue, and Margie Bolton faced as well as everybody who has done these questionnaire type of things, is that the people to whom you are asking these questions can't really say positively, "I only went to x-depth, I stayed x-number of minutes." Until you have that sort of precision, you are always going to have a question.

BANGASSER: That is true.

FIFE: Maybe that is inevitable, but maybe there is a way around that.

NUNNELEY: There is one controlled environment, and that is the hyperbaric oxygen treatment chamber. As those proliferate, and you have more and more female attendants with those, you could eventually compile data.

FIFE: Of course normally when you put a woman attendant or put any attendant in the chamber with a patient, you try to be very cautious. You are not pushing the patient or the attendant.

NUNNELEY: But if you find a difference between bends incidence between male and female in that situation--

MAGALETTA: I wonder if we couldn't put this to rest. It is the only thing that we have studied that doesn't have animal studies. Why don't we just take a bunch of sheep, male and female, a bunch of goats, dogs, chicks, rabbits, and dive them and see what the difference is?

FIFE: Because they are not human.

LANPHIER: That is not going to prove a thing.

MAGALETTA: Well, why are we using the same animals to prove anything else then?

LANPHIER: Well, we are not really trying to prove things. We are trying to get leads on what might be--

MAGALETTA: That is what I am saying. We don't really have any good evidence that there is any lead there. Why don't we at least see what the animals show.

NUNNELEY: Chrisanthou does a lot of studies of decompression sickness in rabbits. He always presents the statistics for the male and the female rabbits separately and says, "There wasn't any difference, so we pooled them." He did it this year, and it was very interesting because he found that a dive disturbed the blood brain barrier for a considerable period after the dive.

FIFE: Well, we know that.

NUNNELEY: It seems to me that it ought to be a good way to treat meningitis. But anyway, he found no difference in the male and female rabbits.

FIFE: Hyperbaric oxygen also will open the blood brain barrier. That is an interesting story which probably isn't related to this, but there seems to be more than one blood brain barrier pathway.

I wonder if at this point, if no one has come up with any other possible things, what about looking at the list we have now and try to put them in some kind of priority order as you view them. Can we prioritize these items? First, which one the these do you think is perhaps the most important item to look at.

BANGASSER: Pregnancy and the outcome of divers.

MAGALETTA: Could we add into that hyperbaric oxygen therapy as well?

FIFE: Fine. Pregnancy and HBO. Now, what would be your view of the next most important item?

NUNNELEY: In terms of commonness of the problem, I wonder about the cold.

FIFE: The temperature, thermal factors. Would you say that thermal response of males versus females and thin versus fat?

HONG: Independent of body fat.

NUNNELEY: We want to control for fat.

CREE: Is that related to body composition?

FIFE: Yes, it really is related to body composition.

NUNNELEY: No. I would say that the body composition is more related to the DCS problem because that either has to be something in the circulation or something where the gas goes and hides.

FIFE: So you are thinking of control for fat only being skin thickness?

NUNNELEY: Yes.

FIFE: Does anybody have any objection to that?

NUNNELEY: You would have to do multiple measurements all over the body because of the distribution.

LANPHIER: Why don't we wrap up these things and include fat such as looking into the method of determining body composition, and then also thermal responses. It would make a very nice package.

HONG: Yes, there are some interrelations there.

FIFE: That is easy to do.

MORGAN: One other comment in connection with that. I think the idea that has been introduced here is that using body composition rather than body fat is important. You could yoke males and females such that you had two 79 kilo subjects, but their lean mass, muscle mass might be quite different. It would seem important to consider body composition rather than weight or fat alone.

FIFE: It would seem to me that when a program like that was put together, you would want to be comparing men of the same skin thickness with women of the same skin thickness.

NUNNELEY: But also compare little men with big women to try and eliminate the muscle mass difference.

FIFE: So we will assume that is all included. What about the idea of putting the older diver, in reference to bends and other things, as fairly high up on our list. There are more people reaching older age who continue to dive actively. Perhaps that may be more important than we really think about.

KEY: Have there been any studies on it?

LANPHIER: I would certainly give the female susceptibility to decompression sickness question a high priority, and I wouldn't at all mind adding age in there as a factor.

NUNNELEY: Then you are going to raise the suspicion that older women are more susceptible to the bends.

FIFE: If we can come to a consensus, fine. It looks like we can say priority three and four or three and three-A are female susceptibility and the older woman diver. Are they of equal importance?

LANPHIER: Say that once more.

FIFE: I am trying to see if we can come up with a number for the female susceptibility to decompression sickness and the older diver.

LANPHIER: The effects of gender and age on decompression sickness.

FIFE: That would be number three then if we are still in agreement.

HONG: Number two should include not only the gender difference, but age.

FIFE: Are you talking about body composition now?

HONG: Right.

FIFE: We will try that and see how they work.

We are down to where, as I see it, we really have only three or four. The bone density on older divers with calcium and estrogen, and I don't know whether that needs to be treated as a separate item, or if that is part of our--it is not really susceptibility.

LANPHIER: It seems to me that that one, I don't see why that is particularly related to diving. I think better work on that in general would be the answer.

NUNNELEY: It is a question of keeping a watch on the unfolding knowledge of active aging.

FIFE: It looks like we are down to really three. One is the definitive work on shark attractants, a study of the pregnancy outcome of divers--and women related to oxygen consumption. Is that women related to oxygen consumption something that is really sufficiently important to raise at this point?

Suki had mentioned that women utilize less oxygen per lean body mass than men, and they handle--

NUNNELEY: But if we are mismeasuring lean body mass, that might explain the whole thing.

HONG: Actually the difference is much greater than that. It is a metabolic response. I don't see any way that we can account for this finding.

NUNNELEY: Does it go in with the cold water question?

HONG: Yes. That is what we have said already, cold water.

FIFE: So we include O_2 consumption in that.

INNES: I have a question about the shark issue. Are we not doing there somewhat like Dr. Nunneley was talking about with decompression? I am not convinced that sharks attack women any more often than men.

FIFE: The probabilities are that when all the smoke goes away they are not. Right now, everybody has an opinion, but nobody has really good data. Maybe you don't care about the data.

INNES: It is not that I don't care about the data. I have had questions from students about, "Am I more likely to get attacked by a shark when I am on my period." My answer has been no.

FIFE: You don't have any concrete evidence.

INNES: I don't necessarily have any evidence, but why would we even think that, just because naturally sharks are attracted by blood?

CLARK: There is evidence that sharks are attracted by blood. Show a shark swimming through the water that there is blood in its path, and they can detect minute amounts of blood. But whether they can detect menstrual blood I don't think has ever been tested. Blood is the basis for that.

NUNNELEY: Maybe somebody better find out how good tampons are.

CLARK: That would be another thing, the woman menstruating swimming through the water not wearing anything, or is she wearing tampons? No one brings up the tassette which is very interesting.

BANGASSER: I didn't even know it was still around.

CLARK: Tassette cups are the only things you can empty under water, you can change under water. It was a handy thing in the days when I wondered what I was going to do if I was going to be in the water on a boat for 6 hrs. That was very handy, the tassette cup. I am sorry it is not around any more.

BANGASSER: I haven't seen them for about 10 yrs. Also, there was a paper which stated that in Australian beaches where they had 50 percent female swimmers, that there were no more shark attacks on women compared to men.

FIFE: Well, I now understand there were fewer than 50 percent. When I talked with Baldridge who did at least one of those studies, and looked at the shark attack files, it seemed there were too many variables. For example, the men were inclined to go off into deeper water than the women. There were other variables that left you still unable to properly evaluate the data. When I talked to him on the phone, he agreed with that. And I questioned whether there is a difference in shark response to hemolyzed or nonhemolyzed blood. You probably are dumping in the water some of both when you chum. This idea that hemolyzed blood actually repels them which is what one of the articles says, just seems to me suspect. This needs to be studied under controlled conditions.

LANPHIER: That belongs on the list, but not at the top.

FIFE: That would be number four. The matter of a questionnaire type study on the pregnancy outcome of divers should be considered.

BANGASSER: What do you mean by pregnancy outcome?

FIFE: George had suggested that we start tracking women who had dived when they were pregnant, something like you had done, but with a much more detailed and carefully controlled questionnaire.

WACHHOLZ: That should be higher on the list than shark attack.

BANGASSER: I thought it was part of number one.

LANPHIER: I did, too.

NUNNELEY: Just record keeping in general is what you would like to see.

FIFE: It looks like what we have done then is drop these to a total of five major questions. I think some of you felt that bone density studies did not need to be on our list. Is that right?

NUNNELEY: I think it could be mentioned as a concern, but the research is already being done under other auspices.

LANPHIER: How specific of a concern is it in diving? I would think the answer would be relatively little compared to just ordinary life.

FIFE: I agree. As I see it then, it looks like the order of our list now is as follows: Item one is pregnancy, the fetus, HBO, and the outcome of

pregnancy on divers for whom we can get records. Item two would consist of thermal response of male and female with control for fat and body composition by gender. Number three would be the effect of gender and age on decompression sickness which would include consideration of some of the possible mechanisms such as platelets, sludging and so on. Number four would be some more definitive work on shark attractants, male and female. You know, it could be that it may not be menstrual fluid. It could be sweat, other types of pheromones to which some animals are more responsive. Anybody have any objection to that?

WACHHOLZ: It might have been covered earlier, maybe I missed it. I just want to come away with an understanding on pregnancy, diving while pregnant at shallow depths. I have heard some people say down to 30 ft is okay, and I have heard others say, "No, it is not." I have heard the argument that you shouldn't, you could have an air embolism at any depth, and that the treatment might be more harmful. Is that not worth mentioning specifically? Is that not shared by anybody?

FIFE: Look at this slide which is the one that has not been published. We put an ultrasonic flow meter around the umbilical artery. Some people think that it makes an animal more prone to bends. These animals then were taken down to various depths and for various times. You can see that here, we showed their bottom time for 40 min at a depth of 41 ft, and that leveled off. So we stayed 24 hrs at 41 ft, and we could not detect any fetal bubbles on decompression at 30 ft per min.

Now if you presume that the animal is more susceptible to bubbles because of the Doppler, then this would look fairly good. But again, in my mind it was only a pilot study so we didn't publish it. But it may mean that at least it is okay for sheep to dive to 41 ft while they are pregnant.

WACHHOLZ: I would thoroughly agree. It is fine for sheep to dive as long as they don't go deeper than 41 ft.

FIFE: So when people recommend 33 ft for humans, there really isn't any concrete basis for that unless you feel comfortable saying we back off from the sheep data.

WACHHOLZ: Make it an even smaller risk. Make it 12 ft in a swimming pool. You are a scuba instructor, female, and you are pregnant What should these people do? Not dive because of what?

FIFE: I am not going to tell them not to dive, but on the other hand, at 12 ft you can embolize.

WACHHOLZ: Yes, you can, but the risk is no greater for those women than for men.

FIFE: But the consequences of having to treat an embolism in a pregnant female is not a risk I would like to assume.

LANPHIER: Could be. We don't even know that.

WACHHOLZ: Would anyone disagree with that?

INNES: But on the theory, you are saying don't dive because you could embolize. There are a lot of accidents that can happen to pregnant women in everyday life that might make their treatment more difficult because they are pregnant. You are not going to tell a pregnant woman to stay in four walls and close the door because if she walks out there and she gets run over by a car, and she has to be put under by an anesthesiologist, there might be a greater chance to damage the fetus.

FIFE: But she is not going to go to a doctor and say, "Do I have to stay out of a car?" It is not fair to put a physician in the position of condoning something they didn't have to do.

INNES: I agree with that. It shouldn't be the physician's decision. It should be hers. I am just attacking this idea that because you could get an embolism and treatment is more difficult or hazardous for pregnant women than nonpregnant women, then somehow you shouldn't go 12 ft in a swimming pool. I think you shouldn't put it on the doctor. It should be an independent decision.

LANPHIER: I don't think that most people would find that a very compelling thing. I mentioned it in connection with deliberately doing tests of this sort. I probably wouldn't because if something did happen, all hell would break loose.

This whole question, I think, Sue, is probably perfectly correct in saying that diving down to 30, 33 ft, whatever it is, is okay. but I have not one damn bit of evidence for that.

BANGASSER: Do we have any proof that diving for anybody down to 30 ft is okay? When I was pregnant, I dived to 30 ft once I knew I was pregnant. I can see how the organizations and associations have to be so careful because of legal reasons for what they say. Realistically you are saying that we can't prove that diving to 30 ft is okay for a pregnant women, but you also can't prove it is okay for anybody.

NUNNELEY: There is aseptic bone necrosis that they are now finding through electron microscopy which actually occurred in bone that we never knew of before, which may have a debilitating effect on us.

FIFE: On the other hand, aseptic bone necrosis is something that you can get from taking cortisone, being drunk, a whole lot of other causes besides diving.

It seems to me, as an attorney, if some woman came to you and said Dr. So and So said I could dive to 33 ft, and here is my kid, and he has a problem.

INNES: No doctor would tell her that though.

LANPHIER: If we put that in our report they might.

INNES: I thought we determined that we weren't going to put it in the report.

LANPHIER: I hope we won't.

FIFE: I agree. But I thought that somebody wanted to bring up, "How deep is safe."

INNES: I think George's point was very good. If your patient comes to you and says, doctor, I want a yes or no whether I can dive to 33 ft, it is back to the old thing of putting the doctor up on a pedestal, and then he is a god and has to give the right answer for all sorts of decisions. That is when it gets into a psychology thing of a doctor saying, to the patient, "Let's sit down and talk. I don't have that answer. I can tell you where to go to do the research if you really want to do it, and look at it and make a decision, but I don't know."

FIFE: On that note we must conclude our discussion.

We have reviewed a number of studies upon which many physicians, diving instructors, and divers have based their decision concerning diving. Some of these studies now appear to have previously unrecognized weaknesses, while others seem to provide solid bases for decision making.

We also have identified a number of areas which need further, rigorous study. We encourage all of those who have the capabilities to attack these questions to do so in the near future.

GREENBAUM: Thank you all for participating.

LIST OF PARTICIPANTS
(In order of Presentation)

WILLIAM P. FIFE, Ph.D. (Chairman), received his Ph.D. in Physiology at the University of Oregon School of Medicine in 1962. He served as Associate Chief of the USAF Aerospace Medical Research Division at the School of Aerospace Medicine from 1962 to 1967. Upon retirement from the Military Service he became a Professor of Biology at Texas A&M University where he served as Department Head of Biology, Associate Dean of the College of Science, and Associate Vice President for Academic Affairs of the University. He now is Director of the Texas A&M Hyperbaric Laboratory.

EDWARD H. LANPHIER, M.D., is not only a physician, but also an ordained minister. He received his medical degree from the University of Illinois College of Medicine in Chicago in 1949, and served his internship at the University of Pennsylvania. He remained there for a postdoctoral program, working in respiratory physiology with the famous Dr. Julius Comroe. Dr. Lanphier graduated from the U.S. Navy Medical Officers course at the Deep Sea Diving School, and from the Submarine School, later becoming the Assistant Medical Officer and Physiologist at the Experimental Diving Unit. In 1958 he served as the Diving Medical Officer for the nuclear weapons tests at Eniwetok, then as Medical Officer for a Navy "Frogmen" Underwater Demolitions Team. In 1958, he joined the Department of Physiology in Buffalo, NY, where he established a new laboratory for underwater studies, remaining there for 13 years. He left Buffalo to attend a theological seminary, graduating into the priesthood. Dr. Lanphier now is a senior scientist in Preventive Medicine at the University of Wisconsin, Madison, where he founded the diving activities of the Biotron Laboratory. He has conducted a number of studies related to pregnancy and diving.

SUK KI HONG, M.D., Ph.D., received an M.D. from Yonsei University (Seoul, Korea) in 1949 and a Ph.D. from the University of Rochester in 1956; since 1975 he has been Professor of Physiology at the State University of New York at Buffalo. He was Professor and Chairman of Physiology at the University of Hawaii (1968-1975) and Yonsei University (1959-1968). He has been actively engaged in diving research since 1959. He extensively studied the physiology of Korean breath-hold women divers, and documented various adaptations of various physiologic systems to diving stresses. More recently, he has been conducting studies comparing gender differences in responding to diving stresses, especially cold water stress, and has been extensively involved in many saturation dives in which he studied the long-term effect of high pressure stress on human physiology. He is a member of many societies, including the Undersea and Hyperbaric Medical Society (UHMS), where he served the society as a member of the Executive Committee for 2 years and is currently Vice President. He also served as a member of the Editorial Board of Undersea Biomedical Research. In addition, since 1972 he has been an advisory member of the U.S.-Japan Panel on Diving Physiology and Technology, and as the U.S. Coordinator for the U.S.-Japan Cooperative Diving Research Program.

SARAH H. NUNNELEY, M.D., received her medical degree in 1967 from the University of Minnesota. In 1970 she became board certified in Preventive Medicine from Ohio State University, School of Medicine. She is also board certified in Aerospace Medicine. Dr. Nunneley currently is Associate Editor of the journal *Aviation, Space and Environmental Medicine*, and is guest editor for the *Journal of Applied Physiology* and *Medicine and Science in Sports*. Dr. Nunneley has authored or co-authored more than 40 papers on heat and cold, exercise, and acceleration stress. At the present she is conducting research at the USAF School of Aerospace Medicine in thermal stress as well as on problems related to female aircrew members.

WILLIAM P. MORGAN, Ed.D., F.A.C.S.M., is Professor of Physical Education and Director of the Sport Psychology Laboratory at the University of Wisconsin-Madison. He received his doctorate from the University of Toledo with a dual major in psychology and physical education (exercise physiology), followed by postdoctoral training in the Institute of Environmental Stress at the University of California, Santa Barbara. A Fellow of the American College of Sports Medicine, American Psychological Association, and the American Academy of Physical Education, he has specialized in sport psychology with particular emphasis on the psychobiologic interaction of exercise, sports, and mental health. He is the editor of *Ergogenic Aids and Muscular Performance, Contemporary Readings in Sport Psychology,* and coedited a forthcoming volume, *Exercise and Mental Health.* Dr. Morgan has also published numerous papers involving personality, perception, hypnosis, motivation, psychopathology, and maximal physical performance. He has served as a consultant in sport psychology to athletic teams at the University of Wisconsin-Madison for the past 15 years, and this consultation has involved research as well as applications. Dr. Morgan has conducted research with elite athletes and Olympic teams in sports such as distance running, rowing, swimming, and wrestling. This research led to the development of a "mental health model" for use in preventing the onset of staleness, as well as enhancing performance. Dr. Morgan was recently reappointed to the USOC Sport Psychology Committee for the current quadrennium, and he serves as a consultant on the elite distance runners' and swimmers' projects sponsored by the USOC Sports Medicine Programs. Dr. Morgan's laboratory is currently supported by a Sea Grant Award, and his research group is attempting to develop a psychobiologic characterization of scuba divers who are judged to be at risk.

SUSAN A. BANGASSER, Ph.D., received her B.S. in chemistry from Northwestern University, and her Ph.D. in biochemistry from the University of Illinois Medical Center. She carried out a postdoctoral program in immunology at the City of Hope in California. Dr. Bangasser became a NAUI scuba diving instructor in 1974, and has written numerous articles on diving physiology, with a special interest on women and diving. She is co-author of a book, *Women Underwater*, and has contributed to the NOAA Diving Manual. She also conducted the Medical Aspects of Women

Divers Survey in an effort to gather information on physiologic concerns of women divers.

GEORGE E. MAGALETTA, M.D., received his medical degree from St. Louis University School of Medicine in 1956, and is board certified in obstetrics and gynecology. He also is as Assistant Instructor in the P.A.D.I. scuba program, and is a graduate of the Physicians Hyperbaric Training Program sponsored by NOAA and the Undersea and Hyperbaric Medical Society. Dr. Magaletta has served as Diving Medical Officer with the Institute of Nautical Archaeology, and has worked with that group in Turkey and with the Western Australian Maritime Museum in Thailand. He has a keen interest not only in diving, but also is women in space.

SUSAN M. INNES, is an Attorney-at-Law, a certified N.A.U.I. scuba instructor, and is actively engaged in diving training and education. She has assisted in certifying more than 100 students. She has published several papers on the legal aspects of diving, and on the liability of instructors. Ms. Innes is especially interested in teaching "problem" divers and those who are handicapped. She now practices law in New Orleans, Louisiana.

BUNNY KEY graduated from the University of Houston in the field of education, with primary interest in physical education, and she has been a YMCA certified scuba diving instructor for many years. She also is a graduate of the Ocean Corporation Commercial Diving School where she taught and was a member of their Nuclear Dive Team. Ms. Key has had considerable commercial diving experience and now has her own diving company based in the Houston area.

LINDA MOROZ started scuba diving in 1979 and soon achieved the level of divemaster. She joined the U.S. Coast Guard in 1980 and graduated first in her class. On her first assignment she obtained a captain's license and qualified as a boat coxwain aboard a number of the Coast Guard rescue vessels. Ms. Moroz graduated from the Navy Diving School first in her class and now is the only female member of the U.S. Coast Guard's Atlantic Strike Team divers. She primarily is a hard-hat diver. Her team was one of those involved in recovery of the Challenger.

CHRISTOPHER WACHHOLZ, R.N., is a certified assistant scuba instructor and has been an avid recreational diver for 16 years, and has been Assistant Director of the Divers Alert Network (DAN) since July 1983, where he is directly involved in the development of the DAN membership association now numbering over 13,000 scuba divers and diving professionals. He is responsible for DAN fund-raising activities, dive accident data collection, and maintenance of the emergency hotline's information resources. DAN serves the divers of the United States, Canada, and Caribbean with a 14-hour emergency hotline, a non emergency information line, and advocates for divers on issues of diving safety, Mr. Wachholz is a registered nurse and is currently working on an MBA at Fuqua School of Business, Duke University. In addition to managing

the day-to-day operations of DAN, he backs up DAN's on-call physicians for diving emergencies, fields many of DAN's non emergency medical questions, and is editor of DAN's newsletter, *Alert Diver*.

EUGENIE CLARK, Ph.D., was Founding Director of Mote Marine Laboratory, and earned her doctorate at New York University. Her search for the answers to questions about sea life has taken her around the world and below the waters of the Seven Seas. She has carried the flag of the Society of Women Geographers to Ethiopia, as well as underwater off Japan and Egypt. She has also carried the flag of the National Geographic Society to Egypt, Israel, Australia, Japan, and Mexico. Dr. Clark is a Professor of Zoology at the University of Maryland and has lectured at over 60 colleges and universities in the United States and in 19 Foreign countries. She is an accomplished and prolific writer and has contributed more than 100 articles to scientific journals and popular magazines, and is the author of two books, *Lady With a Spear* and *The Lady and the Sharks*. Dr. Clark has been diving with sharks for more than 30 years and has been injured by a shark only once. Driving to a lecture with a shark jaw on the front seat of her car, she was forced to make a sudden stop. She reached out to grab hold of the jaw and was cut on the hand by its teeth!

NANCY RIEGLE HUSSEY is director of Undersea Resources Coordination Center, a consulting firm that assists scientific, industrial, philanthropic, and governmental clients plan and develop projects in the marine environment. As a consultant, Mrs. Hussey specializes in facilitating interpersonal and group communication and liaison, generating ideas and concepts, developing strategic plans, and organizing human and financial resources to achieve project goals. Her participation in marine-related endeavors began in 1970 with Tektite II, the joint business, academic, and government program which tested the human ability to live and work beneath the sea for extended periods. Subsequently, she has been involved in or directed projects including the National Plan for the Undersea and Hyperbaric Medical Society, the NOAA Dive Manual, development of a biomedical research program at the University of Southern California, evaluation of marine research opportunities in the Caribbean, and development of private ventures engaged in hyperbaric medical treatment and physician training. In addition to the previous Women in Diving workshop, Mrs. Hussey has participated in several UHMS endeavors and was instrumental in organizing and funding this effort.