NAVAL MEDICAL RESEARCH INSTITUTE
BETHESDA, MARYLAND

79-13

SHOULD DIVERS USE DRUGS?

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UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER (14) NMRI-79-13	2. GOVT ACCESSION NO. / 3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) (6) SHOULD DIVERS USE DRUGS?	5. TYPE OF REPORT & PERIOD COVERED (9) Medical Research Progress Report
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) (10) J. M. Walsh	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Medical Research Institute Bethesda, Maryland 20014	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS M0099.PN.003.3017 Report No. 1
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Medical Research and Development Command (11) Bethesda, Maryland 20014	12. REPORT DATE May 1979
	13. NUMBER OF PAGES 3 pages
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Bureau of Medicine and Surgery Department of the Navy (12) Washington, D.C. 20372 6 pp	15. SECURITY CLASS. (of this report) UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release and sale; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

(16) M0099PN (17) M0099PN003

18. SUPPLEMENTARY NOTES

Walsh, J. M. 1979. Should divers use drugs? Faceplate 10(1):20-23.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Diving
Drugs

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Through research, we know that the effects of drugs in an organism do change under hyperbaric pressure, and that these changes are often unpredicatable. This discussion will provide background information, both physiological and psychological, which reveals the complexities involved in determining what effects a particular drug may have under hyperbaric conditions. The general recommendation, based on the research, discourages the use of any medication while diving.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE S/N 0102-LF-014-6601

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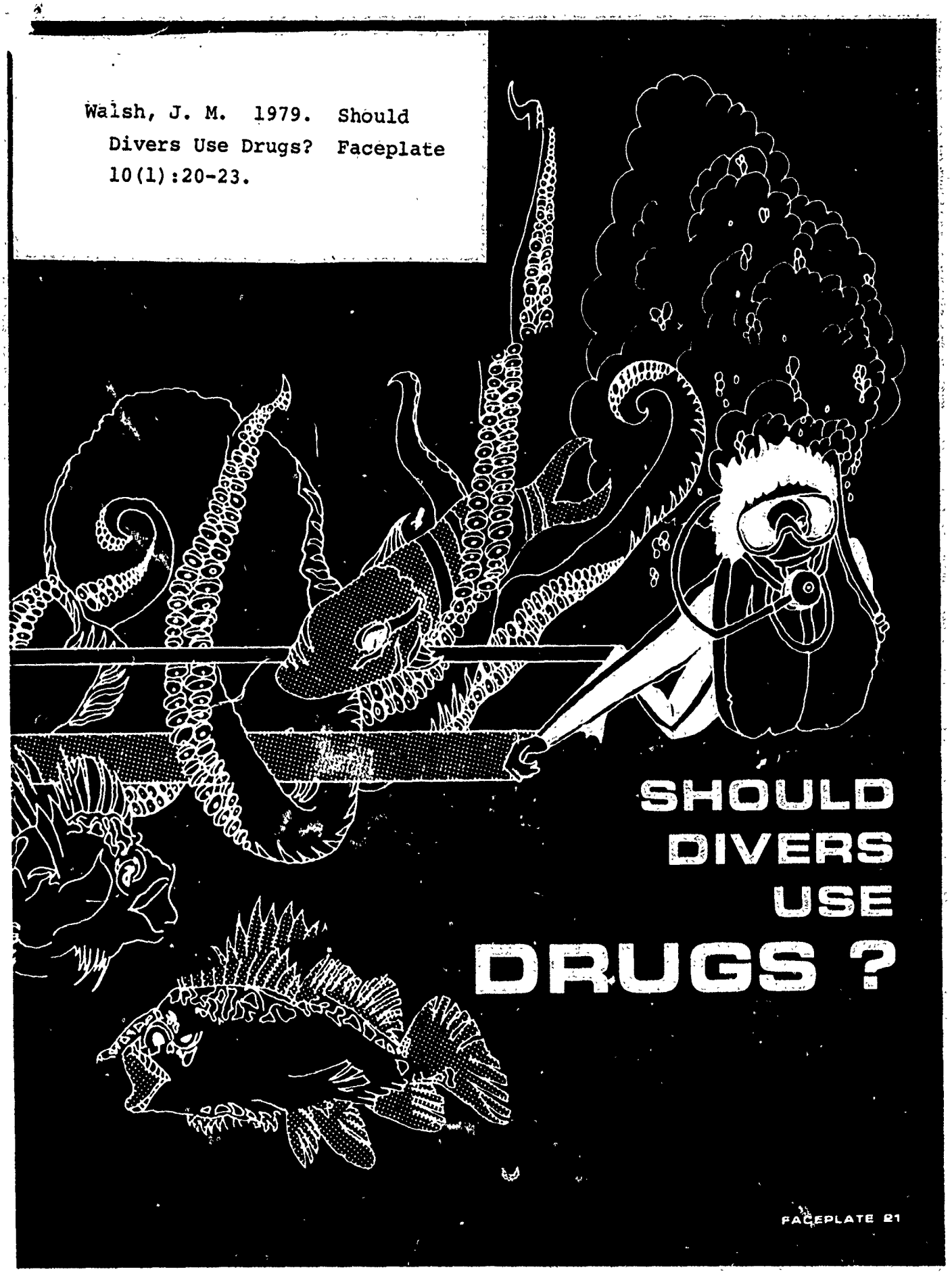

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The title of this article may sound somewhat ominous, so I'd like to define and clarify what I mean when I talk about "drugs." Drugs come in many forms; they can be ingested, injected, inhaled, and even absorbed through the skin—and we are concerned about all of them.

This discussion will not be restricted to street drugs or to prescribed medications, because we want divers to realize that many substances affecting body chemistry (e.g., aspirin, nasal sprays, alcohol, nicotine, caffeine) are not generally thought of as drugs—but probably should be.

If you follow the scuba literature, you probably have decided, as I have, that there are two schools of thought concerning the use of drugs while diving. The Navy provides no specific instructions concerning medication and fitness for duty; the diving supervisor makes his decision based on the recommendation of the diving medical officer (DMO), and that recommendation may vary considerably from one DMO to another. Some say there are a variety of drugs available that will counteract most minor problems and if you are unaffected by these drugs on the surface, you will be okay in the water. In direct contrast, many DMO's believe that under no circumstance should a diver *ever* take *any* kind of drug within the 24 hours before diving.

Now, it seems to me that there's room for discussion between these opposite opinions. So, I'd like to spend the next few paragraphs examining the facts and trying to evolve some logical recommendations and conclusions.

To begin with, there are many variables that alter the effects of drugs. In reality, there is no such thing as "a drug effect," because a drug never acts exactly the same in all individuals, or even in the same person on different occasions. The action of a drug depends, to a large extent, on the physiological and psychological makeup of the individual at the time the drug is administered and on the prevailing environmental conditions. A partial list of the kind of variables that can modify drug action is shown in Table 1.

Any drug can be toxic if you take enough of it, and people vary widely in sensitivity—so much so that an appropriate dose for one person can be an overdose for another. Let's consider what happens physiologically and biochemically when we dive. In the underwater environment we are subjected to: 1) increased hydrostatic pressure, 2) varying partial pressures of N_2 and O_2 in compressed air, and 3) the interaction of changing gas and pressure with all of the variables mentioned above.

Pressure itself can exert numerous changes in our body chemistry. Many effects are obvious only at very high pressures, but even at the depths that divers are accustomed to, the increased workload of breathing under pressure can cause CO_2 buildup from reduced gas exchange and changes in blood constituents can occur. Cell membranes undergo pressure-induced changes, which may account for numerous hyperbaric phenomena, for example, nitrogen narcosis. Even oxygen, which is needed to sustain life, becomes toxic and can cause pulmonary damage and convulsions when the partial pressure is raised sufficiently. Research dives have shown that metabolic, hormonal, neurological, and cardiovascular changes occur at depths as shallow as 90 fsw.

When you plan to dive, you must remember: Changes in your body are going to occur during the dive, and this makes it tough to predict how a drug will act because so much depends on your physiological state and the environment, both of which are continuously changing. Even under carefully controlled conditions in our laboratory at the Naval Medical Research Institute, we have found that *the behavioral effects of drugs change under pressure* and that the way in which they change is *not* predictable from their surface characteristics.

Research in our laboratory has been concerned primarily with the behavioral aspects of drugs and how they affect neuromuscular coordination, judgment, emotional status, and the auditory and visual systems.

"... the behavioral effects of drugs change under pressure and the way in which they change is not predictable from their surface characteristics."

Our work has focused on three areas: 1) use of drugs to provide hyperbaric medical treatment for divers (e.g., in recompression therapy, and for emergency treatment requiring drugs that would work effectively and safely under relatively high pressures—i.e., up to 1,500 fsw); 2) use of drugs to maximize the number of men available for duty and to prevent the onset of hyperbaric disorders (e.g., a safe, effective drug for sinus problems, or something to prevent nitrogen narcosis); 3) unauthorized use of drugs (e.g., self-medication, drug abuse, or excessive consumption of substances that may be harmful, such as alcohol or caffeine).

The program is designed to comparatively evaluate drug compounds, beginning with studies involving small animals (usually rodents) and then thoroughly evaluating the substance in larger animals (monkeys or dogs) before testing it in human divers. The animals and humans are trained to perform similar complex tasks; then they are treated with the drug and exposed to normal and increased pressure conditions in a dry hyperbaric chamber. Because there are thousands of drugs available on the market, we have selected representative compounds from major drug classes for test and evaluation.

Results of these evaluations have demonstrated how widely the effects of drugs vary when introduced to the hyperbaric environment. Some specific observat'ons follow (* indicates statements based on information where human evaluations have been conducted).

• *Analgesics.** Aspirin and Acetaminophen (Tylenol) have been tested at depths to 180 fsw, and even moderately high doses (3-4 tablets) have not produced behavioral or physiological problems.

• *Antihistamines.** (Benadryl) At prescribed doses we have consistently observed decreased performance, mental clouding, and reduced fine motor coordination.

• *Decongestants.* (Sudafed) Behavioral effects of decongestants under pressure are not as toxic as those observed with the antihistamines, although we have seen some slowing of judgment and coordination. In addition, researchers and clinicians suggest that decongestants may predispose divers to cardiac arrhythmias.

• *Depressants.* Pentobarbital and alcohol have been evaluated, and the effects did not appear to get worse under pressure. However, alcohol intoxication, which can cause nausea or vomiting, would certainly be a problem for the diver.

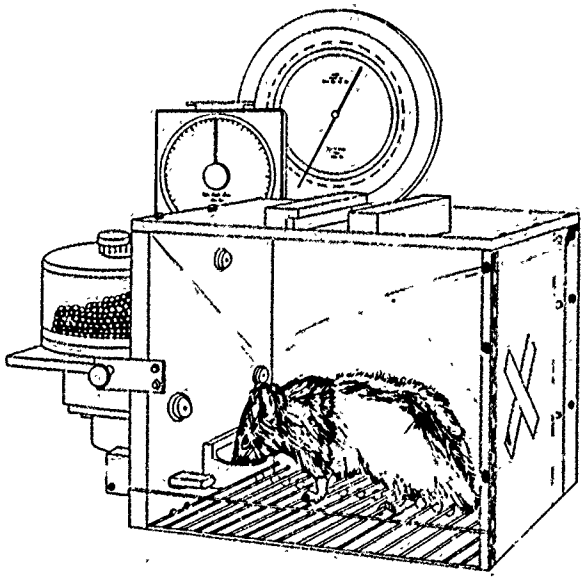
• *Diuretics.* No behavioral effects have been observed at normal doses.

• *Hallucinogens.* Delta-9-tetrahydrocannabinol (THC), the active ingredient in marijuana, was evaluated in animals. The effects of marijuana, which interferes with cognitive processing and neuromuscular control, get worse under pressure, and these effects are magnified as the partial pressure of oxygen increases.

• *Motion Sickness Remedies.* Dramamine*, an antihistamine-type motion-sickness preparation, which is actually a combination of antihistamine and stimulant, does not appear to produce any significant behavioral problems at depths to 180 fsw.

• *Stimulants.* Dexedrine, Methedrine, and the antidepressant Monoamine-oxidase-inhibitors interact with pressure conditions to interfere with judgment and muscle coordination at depths as shallow as 50 fsw. These drugs also may have undesirable cardiovascular effects.

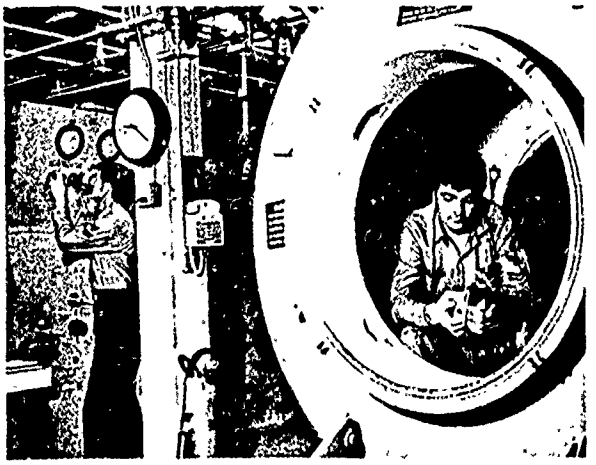
• *Tranquillizers.* Chlorpromazine, Librium, and Valium caused changes in the dose-response curves from animal subjects when these compounds were evaluated under pressure. The magnitude of the effect was dose- and pressure-dependent. In addition, although we have no data for humans, lack of alertness or overconfidence resulting from tranquilizers would certainly be troublesome at 100 fsw.



"The effects of marijuana . . . get worse under pressure, and these effects are magnified as the partial pressure of oxygen increases."

Now, these findings need qualification:

1. Although the studies were carried out under carefully controlled laboratory conditions, they were not done in the water, and the addition of that factor and its associated variables (e.g., cold, anxiety, fatigue) certainly could alter the effect of drugs.



Performance test subject MM1(DV) Chuck Bonner (right) and GMG2(DV) Don Sayre at console of NMRI's hyperbaric test facility.

2. As you've seen, we have not completed all of the evaluations with humans. Some of the conclusions are based on animal research, and, therefore, direct inferences about humans must be made with caution.

In summary, there are three important facts that you should remember when you plan a dive: 1) Changes in your body chemistry occur while diving; 2) many variables affecting drug action can come into play during a dive; and 3) the interaction of these facts (1 and 2) cause drugs to change unpredictably.

Recommendations

- It would be wise to avoid *all* drugs while diving.
- Remember that over-the-counter preparations can be as toxic as prescription or abused drugs.
- If you must dive under medication, be informed. Get full information from your diving medical officer, realize that even the most benign compound may become behaviorally toxic under pressure, and dive with extreme caution.

TABLE 1
PARTIAL LIST OF VARIABLES THAT CAN AFFECT DRUG DISPOSITION IN A DIVER

EXTERNAL	INTERNAL	PHARMACOLOGICAL
Breathing gas	Age	Acute vs. chronic
Current	Allergy	Administration route
Diet	Anxiety/panic	Bioavailability
Pressure (depth)	Cardiovascular function	Dose
Pressure x gas interaction	Circadian rhythm	Excretion
Nitrogen narcosis	Disease state	Metabolism
Oxygen toxicity	GI function	Presence of other drugs
CO_2 intoxication	Infection/fever	Tolerance
Visibility	Pregnancy	Vehicle
Water temperature	Weight	

"It would be wise to avoid all drugs while diving . . . Even the most benign compound may become behaviorally toxic under pressure."