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SHARK HAZARDS ON NAVY AND MARINE CORPS OPERATIONS

**A Discussion of the Impact of Shark Hazards on Navy and
Marine Corps Operations, Equipment, and Personnel**

Mr. B. J. ZAHURANEC

**Oceanic Biology Division
Ocean Research Office**

June 1976

**The Report of a Workshop Held 18 May 1976
at the Explosive Ordnance Disposal School
Indian Head, Maryland**



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FOREWORD

Since the time of World War II, the Navy has been concerned with the hazard of dangerous marine animals. Foremost among these are the sharks.

It is likely that sharks have been recognized as a significant danger to man from the time when man first ventured into shark populated waters. Exactly how much danger there is from sharks depends on a variety of factors including both environmental aspects (water clarity, temperature, depth, location, etc.) and biological aspects (the species of sharks present, their capabilities and behavior). Consequently, it is to be expected that the amount of danger can fluctuate greatly, depending on these and other factors.

In seeking ways to better understand and alleviate this problem, the Navy, largely through the Office of Naval Research, has supported research on sharks for a number of years. The information obtained from such studies can then be instrumental in helping to alleviate the impact of sharks on naval operations. Indeed, it is only through the research supported thus far that we have some appreciation for the remarkable capabilities of these animals that are so well adapted to their environment and to the role that they play in that environment.

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PREFACE

On 18 May 1976 a one day workshop was convened at the Explosive Ordnance Disposal School, Indian Head, Maryland, to discuss the shark hazard and its impact, both direct and indirect, on Navy and Marine Corps personnel, equipment, and operations. The Chairman of the workshop was the Commanding Officer of the School, CDR D. L. Schaible. The Workshop was sponsored jointly by the Office of Naval Research, Ocean Science and Technology Division (NORDA 21, ONR 480), and the CNO Office of Research, Development, Test and Evaluation, R & D Plans Division (OP 987). A total of 24 individuals attended the workshop, including representatives from a wide range of Navy commands, the Marine Corps, and the Coast Guard. Appendix I provides a list of the attendees.

The morning session consisted of a multi-faceted briefing for the attendees. The background history and present status of our knowledge of sharks and shark research were discussed by B. J. Zahuranec and S. R. Galler. Three short presentations on specific topics involving several practical aspects of directed research on sharks were given by J. B. Gregory, James Welch, and Lionel Weinstock. Mr. Zahuranec then concluded with a brief discussion of the ONR view of shark problems and basic research priorities and the chairman brought the morning session to a close.

During the afternoon session, the chairman acted as moderator of a roundtable discussion involving all attendees. All aspects of Navy and Marine Corps operations where sharks could conceivably have an effect were discussed. Appendix II is the agenda followed during the workshop.

The sponsors wish to thank CDR Schaible and the members of his staff for their excellent assistance and cooperation which made the workshop possible.

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SHARK HAZARDS ON NAVY AND MARINE CORPS OPERATIONS

A Discussion of the Impact of Shark Hazards on Navy and Marine Corps Operations, Equipment, and Personnel

A. BACKGROUND

The history of shark research in the Navy is closely tied to the history of the Navy's standard shark repellent, "Shark Chaser". Before the Second World War, if the Navy had an official position with respect to sharks, it was that sharks were largely harmless to an uninjured, alert person in the water. This is understandable since a number of scientists in those days had the same opinion and it had been published widely. After the war had started, however, reports of shark incidents started coming back from the front, especially from the Western Pacific. It is not clear how serious a problem sharks actually were as a direct hazard to men in the water, but they were certainly a psychological threat and began causing noticeable morale problems.

To help solve this problem, an accelerated applied research program was set up to find a chemical shark repellent. It was agreed at that time that to be considered effective enough to be worth distributing to personnel, a potential chemical repellent would have to repel sharks two times out of three or 67% of the time. In addition, feeding was considered likely to be the primary motivating factor in causing sharks to attack humans, so the search began for chemical agents that would keep sharks from feeding.

Shark fishermen had long noticed that if a shark was caught on a fishing line, died, and for some reason was not retrieved before decomposition set in, then further fishing for sharks in that vicinity was useless. In other words, it appeared that rotting shark meat acted as a shark repellent or at least a feeding inhibitor. Tests conducted in a chemical laboratory on samples of rotting shark flesh indicated that the most abundant chemical by-product was ammonium acetate. From other preliminary tests on a variety of chemicals at the Woods Hole Oceanographic Institution that intuitively seemed to be worth testing, maleic acid and copper sulfate showed some promise of inhibiting feeding in dogfish sharks. Maleic acid subsequently proved ineffective and was eliminated. Because of the instability problems with ammonium acetate, it was decided to combine the acetate portion of it with the copper portion of the copper sulfate. Consequently, copper acetate was tested as the active ingredient, to which a black pigment, nigrosine dye, was added in later tests to permit humans to see the chemical cloud in the water. The mixture of 80% nigrosine dye and 20% copper acetate proved to be quite effective, sometimes almost 100% effective, in keeping sharks from taking baited lines or from feeding, even when actively feeding on trash fish being shoveled off the deck of a shrimp boat. These chemicals, mixed on a cake of water soluble wax that dissolved over a three-hour period, became the standard issue "Shark

Chaser". Whether it worked effectively in the field in repelling sharks under combat conditions or not, it certainly helped the morale of the men, which was probably the most serious problem at that time.

But in the post-war period, reports began to surface about instances where Shark Chaser did not work, even to the point where sharks were seen to bite a cake of it, and swim off with black clouds of dye streaming from their gill slits.

As a result of such reports, a conference on sharks was supported by the Office of Naval Research in April 1958 in New Orleans at which participants reviewed what was then known about the biology and behavior of dangerous sharks. One result of the conference was the establishment of a Shark Research Panel under the American Institute of Biological Sciences. A second outgrowth was the publication in 1963 of "Sharks and Survival", edited by Dr. Perry W. Gilbert (D. C. Heath and Co., Boston). "Sharks and Survival" was essentially a compendium of what was known about sharks and the shark hazard up to that time, and as such, is a landmark in the field of elasmobranch biology research.

One of the first recommendations made by the Shark Research Panel was that a comprehensive research program involving basic studies on the taxonomy, behavior, and functional anatomy of the dangerous sharks was essential to understanding the shark hazard. It is essentially this recommendation that has guided the shark research program of the ONR Oceanic Biology Program through the years.

In the earlier years, emphasis was placed on the construction of facilities for the maintenance and study of elasmobranchs as well as understanding their requirements under artificial or semi-natural conditions. Emphasis was also placed on studies of shark taxonomy and on the gathering of information of shark attacks on humans since it was not well understood how to distinguish many of the different species of sharks, nor how many are dangerous to man nor how dangerous they are. As a result of these studies, the taxonomy of the larger sharks is now fairly well known, and through the comprehensive analysis of the records of a large number of shark attack cases, Dr. David Baldrige produced in 1974 a definitive report about human shark attacks entitled "Shark Attack: A Program of Data Reduction and Analysis (Contributions from the Mote Marine Laboratory, Vol. 1, No. 2)".

A major area of continuing investigation is that of shark behavior. While several recent studies on the behavior of individual species of sharks clearly indicate that shark behavior cannot be considered unpredictable, as with any other species of animal, understanding their behavior depends upon understanding their sensory capabilities. Consequently, the shark research program over the past several years has emphasized studies on the sensory biology of sharks, their vision, hearing, chemoreception, and weak electric field sensitivity. Recent findings in these and other areas were discussed at a 1974 conference on shark research supported by ONR and summarized in the report on the conference entitled "Shark Research: Present Status and Future Direction" (Office of Naval Research, ACR 208).

B. PRESENT STATUS

In general, research on sensory capabilities of elasmobranchs is being drawn to a close. Research on shark behavior, especially field studies concerning diurnal migration patterns, territorial behavior, and feeding cycles is continuing. Information from this

type of fundamental research can also be of immediate value to the swimmer/diver community.

Past research on sensory capabilities has led to the finding that sharks are attracted to low frequency sounds. Some special cases are being examined by more direct studies. Investigations are underway to determine if the acoustic energy emitted by a strumming cable moored in an ocean current attracts sharks and induces them to bite. In another investigation, Navy, Marine Corps, and Air Force helicopter pilots and crewmen are being asked about their experiences with sharks in the rotor wash area below a hovering helicopter. That sharks might respond to the low frequency sound energy transmitted into the water by a helicopter was predicted by basic research investigations.

A program has been started to investigate a reported shark repellent naturally produced by the Red Sea flatfish "Pardachirus marmoratus". Initial reports involving this flatfish have received wide media coverage, but a careful repetition of the initial experimentation is needed before this finding can be further evaluated.

In recent years, a large number of mechanical or electrical shark defense devices has been developed. Active antishark weapons such as the shark dart or bang stick are useful only in limited situations where physical contact with the shark cannot be avoided since they are of potential risk to the user and require considerable skill to be effective. The shark screen bag, a concept developed by Dr. C. Scott Johnson of the Naval Undersea Center, isolates the survivor from the chemical, visual, and weak electric field senses of the shark.

The Naval Air Systems Command is approaching the shark attack hazard to air crew survivors at sea by development of an operational one man life raft. This approach not only isolates the survivor from the sensory capabilities of the shark, but also greatly reduces heat loss to the water, usually of prime importance for survival. In conjunction with this, and because of its uncertain and limited effectiveness and the widespread general awareness of this ineffectiveness, "Shark Chaser" will no longer be procured by the Naval Air Systems Command and will be deleted from survival equipment lists.

C. DISCUSSION

The following paragraphs summarize the open discussions during the afternoon session of the workshop moderated by CDR Schaible.

1. Swimmer/Diver Operations

The swimmer/diver community views the shark hazard as a problem from both the physical and psychological viewpoints. Their way of dealing with the psychological problem is to initially assure new candidates that there is no problem; that is, sharks are not a serious threat. Their way of dealing with the physical threat is simply to leave the water or not enter it if sharks are sighted. This works only if the timing for completion of the activity or site selection is not critical. Situations where an operation has to be completed, despite the visible threat of sharks, often necessitate deployment of twice the normal number of men with half acting as guards while the other half carry out the task.

Although concern for the potential seriousness of both types of threats was expressed by a number of participants, no quantitative data exists to document the impact of the shark hazard on swimmer/diver operations where no injury occurred. On the basis of anecdotal information, it is clear that the shark hazard is a real and serious one for these situations. But although there is a great deal of anecdotal information, it is not clear how much time has been lost, how many operations changed or cancelled, or how much the psychological impact impairs individual performance in carrying out given tasks. Quantification is necessary to clarify the extent of the problem. Such quantification might be obtained through questionnaires or psychological tests, but the questions asked would need to be very carefully formulated for the results to be valid. Quantitative information regarding interference with operations might be obtained by inquiring directly of the cognizant commands. It is possible that some quantitative data could be obtained by modifying the standard diving log sheets that are routinely filed after every diving operation.

Thus, it may be concluded that on the basis of anecdotal information the shark hazard is a serious and continuing one to the swimmer/diver community but there is little quantitative information to document the extent of the problem. Efforts should be made to obtain the necessary data.

Because of the present lack of a universally effective shark repellent, knowledge of the behaviour, sensory capabilities, and distribution of the sharks that are found in a selected area is critical in planning countermeasures. Knowledge of the capabilities of various sharks, such as their attraction to low frequency irregularly pulsed sounds, could then be put to use for the planning of operations. In the same way, information about feeding habits, movements, territoriality, etc. could also be useful. Such information should be made available to the swimmer/diver community both through training and operationally useful publications.

2. Search and Rescue Operations

The shark hazard is presently considered of reduced consequence to this class of operation. This appears to be the result of several factors: the time of personnel exposure in the water is short; with modern SAR techniques and equipment it is getting shorter; and the number of Navy people exposed at all in the period since World War II has been extremely small.

Though there is anecdotal information that the chemical repellent Shark Chaser, formerly issued as personal survival gear, was of psychological benefit to air crews and other potential survivors, this too needs quantification as was discussed for swimmer/diver operations. It may be that statistical information about whether there is a potential for shark attacks can give some insight into possible psychological benefits. Quantitative information could also be sought of other navies such as the Australian Navy and New Zealand Navy, although they generally employ air safety equipment of U.S. manufacture.

3. Amphibious Operations

Modern amphibious assault concepts very greatly reduce the direct exposure of men in the water. The remaining area of high exposure in this type of operation appears to be night time swimmer/diver operations prior to the actual assault. The impact on swimmer/

diver operations has already been discussed, though in this case, the shark hazard is deliberately treated as being part of the acceptable risk involved.

4. Medicine and Surgery

Problems of shark bites from the viewpoint of medicine and surgery elicit no special consideration. Such wounds are treated in the same way as any other major trauma such as combat wounds, etc. There apparently is no special medical approach or planning in common operational situations with regard to the shark hazard.

5. Fishbite of Deployed Equipment Systems

This appears to be a problem primarily to the oceanographic community, and is normally of minor consequence to overall Navy operations.

6. Recreational Swimming

Recreational swimming, bathing, and diving apparently are the only conditions under which losses of Navy personnel to shark attack have occurred in recent years. The most recent authenticated shark attack on a member of the Navy occurred when LTJG John Gibson was attacked and killed by a shark while swimming off St. Thomas, Virgin Islands, on 20 April 1963. More recently, an incident occurred in 1974 in Limon Bay, Panama, when it was reported that a seaman accidentally fell overboard from a small craft. When the body was recovered, sharks had severed the head and one limb. However, the seaman could not swim so it is not certain whether he drowned first or was pulled under by a shark. In any case, the shark hazard affects this category of naval activities in the same way that it affects the recreation sector of the civilian community. There, the shark hazard is a continuing problem, perceptually acute in some coastal resort areas, usually out of all proportion to the amount of actual destruction.

D. CONCLUSION

The shark hazard is of greatest concern to the swimmer/diver community, and while it is a serious problem, the exact extent of its importance is uncertain because of the difficulties in quantifying such data. Efforts should be made to obtain such quantification, both of direct interference with operations as well as the psychological impact of the shark hazard on impaired efficiency.

Information regarding shark distributions, habits, and behaviour can be of great assistance to the swimmer/diver community in the absence of a totally effective shark repellent. This information should be disseminated to Navy personnel by way of operationally useful publications and training.

The shark hazard is presently of lesser concern in search and rescue operations than other environmental factors such as flotation and preservation of body heat. Perhaps of greatest concern here is the resolution of the most effective lifesaving equipment that will serve other tasks and alleviate the shark hazard at the same time.

With regard to other areas of Navy operations, the shark hazard is considered a less serious problem. Most, if not all, shark related problems could be controlled with the discovery of a completely effective shark repellent. While there was agreement on the importance of continuing research on shark behaviour and distribution, several workshop attendees inquired about the shark repellent secretions of the Red Sea sole "Pardachirus" and expressed the hope that this might ultimately prove to be the source of such a completely effective shark repellent. This is especially important now in view of the recent decision to cease procurement of Shark Chaser, which though limited in effectiveness, had provided some protection under some conditions. It was agreed that the research underway to verify the initial findings on the "Pardachirus" phenomenon and expansion on those findings is a necessary first step toward the goal of a truly effective shark repellent.

E. RECOMMENDATIONS

With respect to the impact of the shark hazard on Navy and Marine Corps operations and personnel, several recommendations came out of the workshop discussions.

1. Quantify, insofar as possible, the impact of the shark hazard both by direct interference with naval operations and the psychological impact on Navy and Marine Corps personnel.
2. As basic research on shark behavior, habits, and distribution continues, disseminate the information in a timely and direct manner to Navy and Marine Corps personnel through operationally useful publications and training.
3. Continue the search for a completely effective shark repellent with the most promising lead at present involving basic research on the shark repellent secretions of the Red Sea sole "Pardachirus".

APPENDIX I

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APPENDIX II

AGENDA

- 0915 Welcome and Introduction
CDR D. L. Schaible, Commanding Officer, Explosive Ordnance Disposal School,
Indian Head, Maryland--Workshop Chairman
- 0925 Historical Background
Mr. Bernard J. Zahuranec, Assistant Program Director for Oceanic Biology,
NORDA/ONR and Dr. S. R. Galler, Deputy Assistant Secretary for Environmental
Affairs, Department of Commerce
- 1000 Status of Research--Information Gained to Date and Introduction to Navy Film
"Shark, Danger in the Sea", Mr. Bernard J. Zahuranec, NORDA/ONR
- 1030 Coffee Break
- 1040 Conclude Status of Research
- 1100 Fishbite Problems on Moored Systems--Current Research, Mr. John B. Gregory,
Program Director for Ocean Technology, NORDA/ONR
- 1110 Helicopters--SAR and Sharks--A Data Collection Project, LCDR James Welch,
Department of Environmental Sciences, U.S. Naval Academy, Annapolis, Maryland
- 1120 Aviation Survival At-Sea Equipment, Mr. Lionel Weinstock, Crew Systems Division,
Naval Air Systems Command
- 1130 An ONR Perspective on Current Navy Problems and Projected Research Priorities,
Mr. Bernard J. Zahuranec
- 1155 Review and Discussion, CDR D. L. Schaible
- 1200 LUNCH
- 1300 Discussion of Impact of Shark Hazards on Operations, Personnel, and Material,
Moderator--CDR Schaible
- Topic #1 Diver/Swimmer Operations
- Topic #2 Search and Rescue Operations
- Topic #3 Amphibious Operations
- Topic #4 Medicine and Surgery

Topic #5 Deployed Equipment Systems and Fishbite

Topic #6 Recreational Swimming by Naval Personnel

1600 Review and Summary, CDR Schaible

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representatives from a wide range of Navy commands, the Marine Corps, and the Coast Guard.

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During the afternoon session, all aspects of Navy and Marine Corps operations where sharks could conceivably have an effect were discussed. Topics covered included: Swimmer/Diver Operations; Search and Rescue Operations; Amphibious Operations; Medicine and Surgery; Fishbite of Deployed Equipment Systems; and Recreational Swimming.