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C S JOHNSON ET AL. NOV 82 NOSC/TR-867 P-WELL-825PDP

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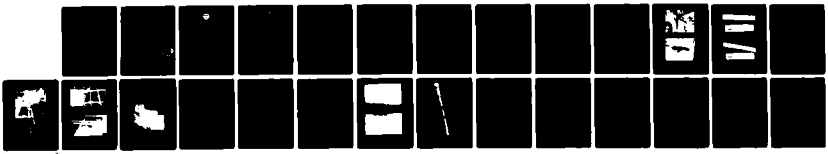

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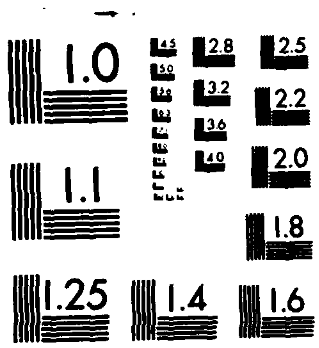

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Technical Report 867

STUDY OF FISH BITE ON THE AN/BQR-15 TOWED ARRAY

CS Johnson Code 5102
MW McManus Code 5141
BL Scronce Code 5141

November 1982

Report for period: February–November 1982

Prepared for
Western Electric Co.
Greensboro, NC 27420

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NOSC

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San Diego, California 92152

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AN ACTIVITY OF THE NAVAL MATERIAL COMMAND

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Commander

HL BLOOD
Technical Director

ADMINISTRATIVE INFORMATION

This Technical Report describes work performed under contract P-WELL 825PDP between 8 February 1982 and 30 November 1982 with funding provided by Western Electric Company.

The authors wish to thank Mr. Ray Keyes and his staff at Sea World for their generous support in making the shark bite tests reported.

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This report describes work done to study the reasons for fish bites on towed arrays. Three tasks were performed. (A) Pieces of boot from the two versions of the AN/BQR-15 towed array were allowed to be bitten by sharks and the damage assessed. (B) The galvanic electric field produced by a submerged titanium array coupling was measured. (C) Pieces of two versions of BQR-15 array were towed through an area of the sea where sharks had been attracted in an unsuccessful attempt to provoke bites on the arrays. Results indicated that large sharks had no difficulty in penetrating the thin version of the BQR-15's boot. The galvanic field of a titanium coupling from

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the thin version of the array is sufficient to be detected by sharks at ranges of less than 15 cm and underwater photographs of the pieces of array showed that the titanium couplings of the thin array and the type of wrappings on the vibration isolation module (VIM) of the large array may be visually attractive to sharks.

OBJECTIVE

Try to determine the causes of fish bite damage to the AN/BQR-15 towed array and propose methods of minimizing damage.

RESULTS

1. Large sharks had no difficulty in penetrating the thin array boot.

2. When a titanium coupling is immersed in sea water the galvanic field generated will be large enough to be detected by sharks at ranges of less than 15 cm.

3. The titanium couplings of the thin version of the array and the tape wrappings on the VIM of the large array may be visually attractive to sharks.

RECOMMENDATIONS

1. Continue making underwater observations of the arrays in the presence of sharks.

2. Test the feasibility of attracting sharks to invulnerable parts of the arrays.

CONTENTS

INTRODUCTION

Sharks and other sea creatures, from time to time, bite mooring lines and other equipment (ref. 1 and 2). Of particular interest in this report are attacks on the AN/BQR-15 submarine-towed-acoustic arrays. Little is known about where or when the attacks occur, because they seldom result in instrument failure and damage and are only discovered at the end of the patrol. Even though the array's operation may not be seriously hampered by an attack, substantial damage can be done (ref. 3). In the case of the BQR-15, most of the attacks occur on the forward part of the array. There are several possible reasons for this. Four of the most likely are listed here.

1. Vibrations from the Vibration Isolation Module (VIM), located at the front of the array, may attract and excite sharks and other fish to bite.

2. The nose cone may collect or excite luminescent organisms attracting bites.

3. Small electric fields which are known to provoke shark bites (ref. 4) may be present at certain parts of the array.

4. Changes in texture or color of the array coverings and connectors may be visually attractive to sharks. In this report, we describe the causes of shark bite damage to two versions of the BQR-15 towed array.

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1. Prindle, B., and Walden. R.G., Deep-Sea Lines Fishbite Manual, Woods Hole, Mass. 02543, 1975.

2. Johnson, C.S., Sea Creatures and the Problem of Equipment Damage, U.S. Naval Institute Proceedings, p. 106-7, 1978.

3. Hyde, J.H., AN/BQR-15 Array Damage Report, Western Electric, Guilford Center, Greensboro, N.C. 27420, 1 April 1982.

4. Kalmijn, A.J., The Detection of Electric Fields from Inanimate and Animate Sources other than Electric Organs, Chapt. 5 in Handbook of Sensory Physiology III, A. Fessard, ed., Springer-Verlag, New York, 1974.

The work was divided into three tasks:

A. Test pieces of the new, thin version of the array to determine the effects of bite damage from sharks.

B. Measure the galvanic electric field produced when the titanium connectors of the thin array are immersed in sea water.

C. Tow sections of both the new and old versions of the array in the open sea through areas where sharks have been attracted.

MATERIALS AND METHODS

TASK A

Sharks were induced to bite short sections of the array by tying fish fillets to the outside, and then presenting this arrangement to sharks via a line run through the center of the array segment. Figures 1a and 1b show this procedure during tests made with a lemon shark (Negaprion brevirostris) at Sea World's shark tank. The same procedure was used to obtain bites from the blue sharks (Prionace glauca) in the open sea. The resulting damage caused by these two tests is shown in figures 2a and b.

TASK B

The titanium coupling from the thin array was immersed into a sea-water-filled plastic tank in a laboratory. The tank measured 80-cm x 68-cm x 15-cm deep, and was filled to a depth of 8 cm with sea water. Corks were placed in either end of the cylindrical coupling, and the portions of the coupling, where the array boot attaches, were covered with an insulating rubber coating to duplicate actual electrical conditions. Supported by a nonconducting thread from each end, the couplings were suspended horizontally at a depth of 4 cm when the measurements were made. The exposed area of the coupling measured 2.5 cm in diameter by 7.8 cm in length.

Electric field measurements were made using three electrodes of a type described in reference 5. Circuitry, the common mode method of noise rejection, was used, and is described in the appendix.

The three electrodes were positioned 2.5 cm apart and in a line at right angles to the coupling's axis. The axis of the coupling was 4.75 cm from the nearest electrode.

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5. Johnson, C.S., Electrical Model of Piscine Electrosensing System, NOSC TR 806, June 1982.

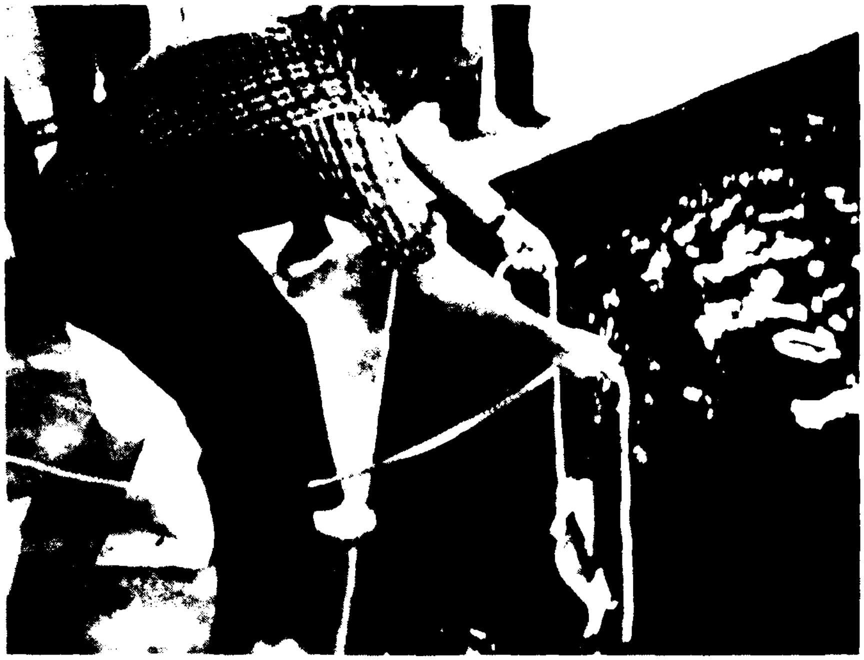

Figure 1a. Picture of a scientist at Sea World holding the ends of a line through a piece of thin array which has fish fillets attached to it to provoke the sharks to bite.

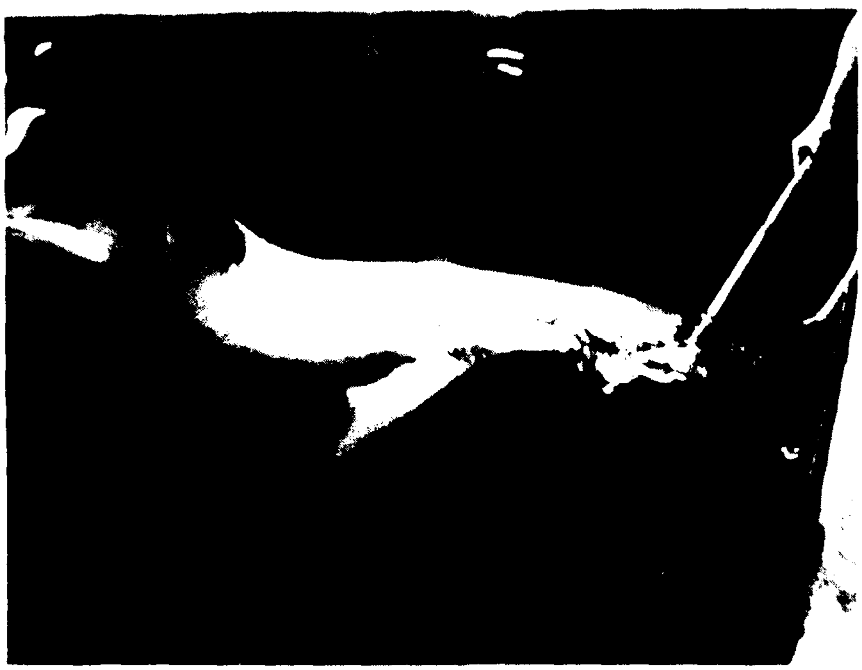

Figure 1b. A 2.7-m, 150-kg lemon shark is shown biting the fish-covered piece of thin array boot.

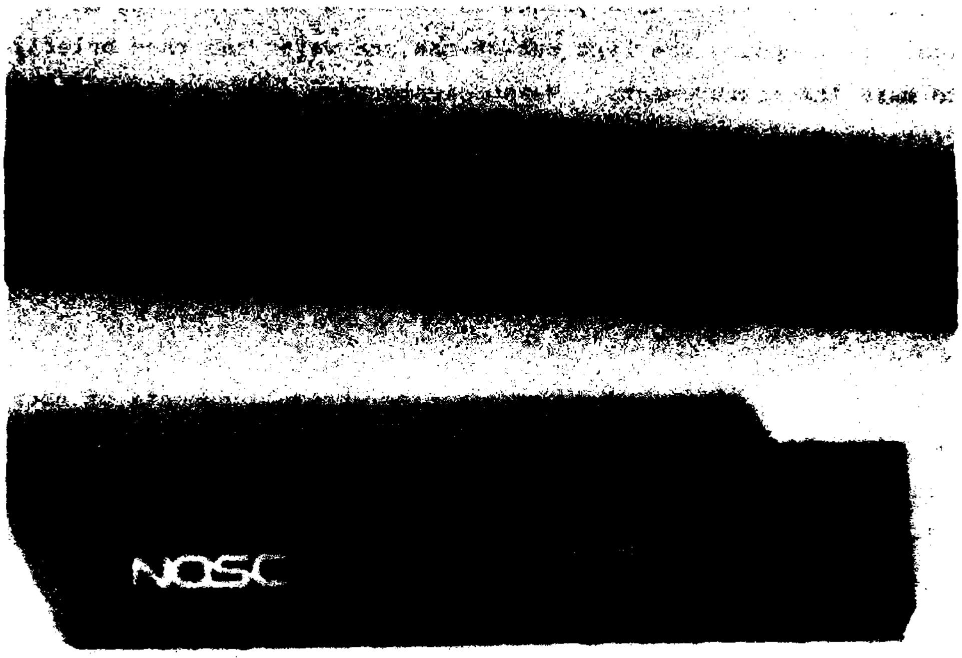

Figure 2a. Shown here are the results of two bites by the lemon shark shown in figure 1

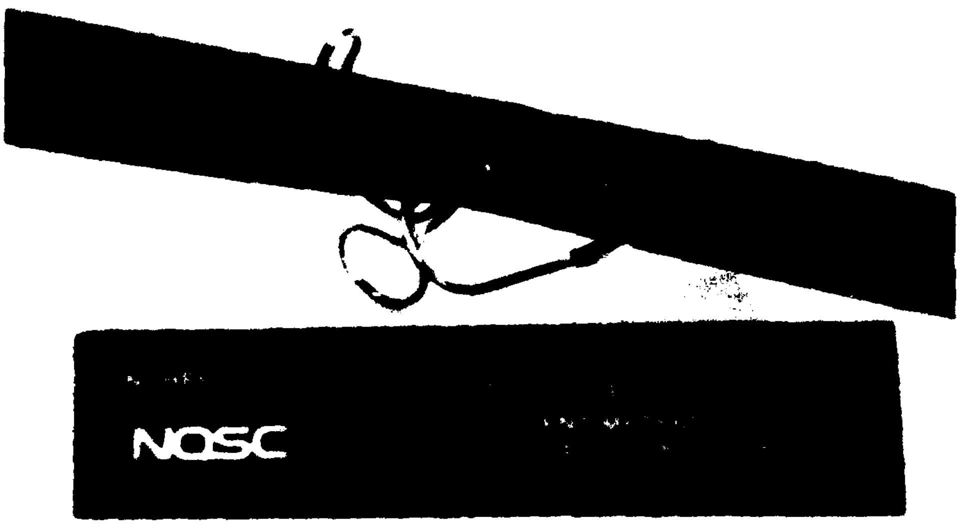

Figure 2b. The relatively small damage done to a piece of thin array boot by a 2-m, 75-kg blue shark.

Since this electronic arrangement is intended for measuring AC or transient fields, the coupling was kept out of the sea water and then briefly submerged to make the measurements. Measurements were made with the coupling in four different axial positions, each 90° apart, but always with the axis of the coupling at right angles to the line of the electrodes. The maximum sensitivity of this arrangement was 2.5 μV.

TASK C

In an effort to induce sharks to bite the arrays, segments of each array were towed through an area of the open sea that had been chummed with ground fish to attract sharks. The array segments are shown in figures 3 and 4a and 4b. A 30-ft Radon built craft (figure 5) was used to tow each array. Chumming was done in two ways. A 58-ℓ garbage can, containing 55ℓ of ground fish mixed with water and frozen, was attached to a large orange buoy and put overboard. Holes had been made in the can to allow the frozen chum to stream out into the sea as it thawed. Chum was also dispensed from the Radon as it towed the array segments (figure 5). Frozen chum was placed in a large rectangular container, and sea water was pumped into the box. The thawed chum passed into the sea over the stern of the boat through an overflow pipe. Two hundred fifty-five (255)ℓ of chum, made up of 45-kg ground fish, mostly mackerel and herring, were dispensed on each trip. The remainder of the 255-ℓ volume was fresh water. A steady towing speed of 4 knots was maintained around a figure-eight course with the floating chum can at the crossover point. It took 6.5 to 7 minutes to complete one of the figure-eight circuits. Each array was towed for approximately 2 hr. Table 1 shows a breakdown of the towing times for the two arrays on the 10 trips made. The location of all the work was in an area 10 nmi west of San Diego, between Ocean Beach and the tip of Pt Loma. During the change-over, from towing one array to the next, more frozen chum was added to the floating chum can.

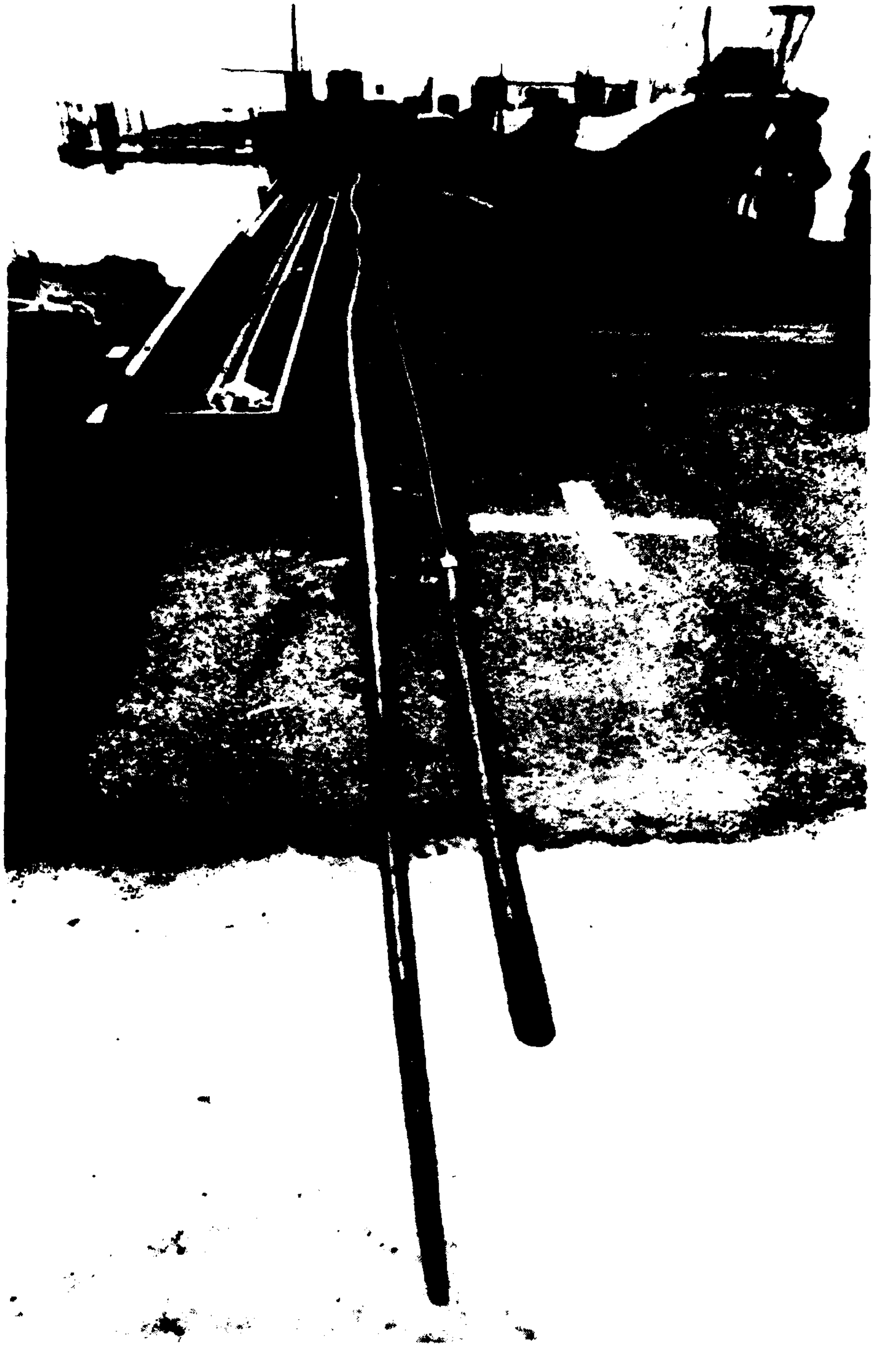

Figure 3. The large and small array sections are shown laid out on the deck in the configuration in which they were towed. Each array section was 22.5-m long with 15 m of cable.

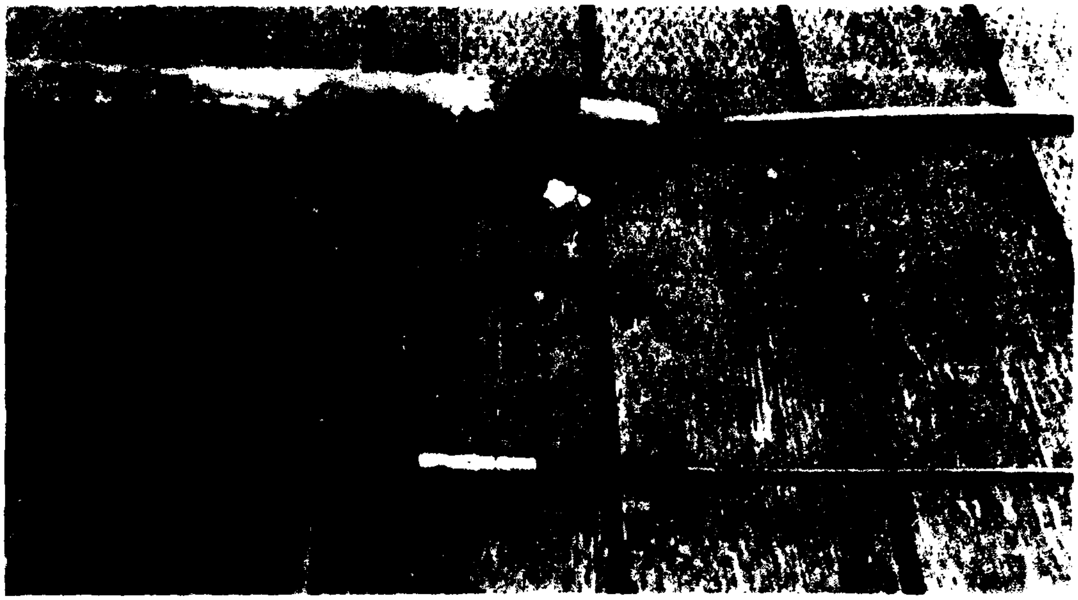

Figure 4a. View of the forward end of the arrays.

Figure 4b. View of the aft end of the arrays. The drogue for the small array was made from a 2.5-m section of 8-cm-diameter hose.

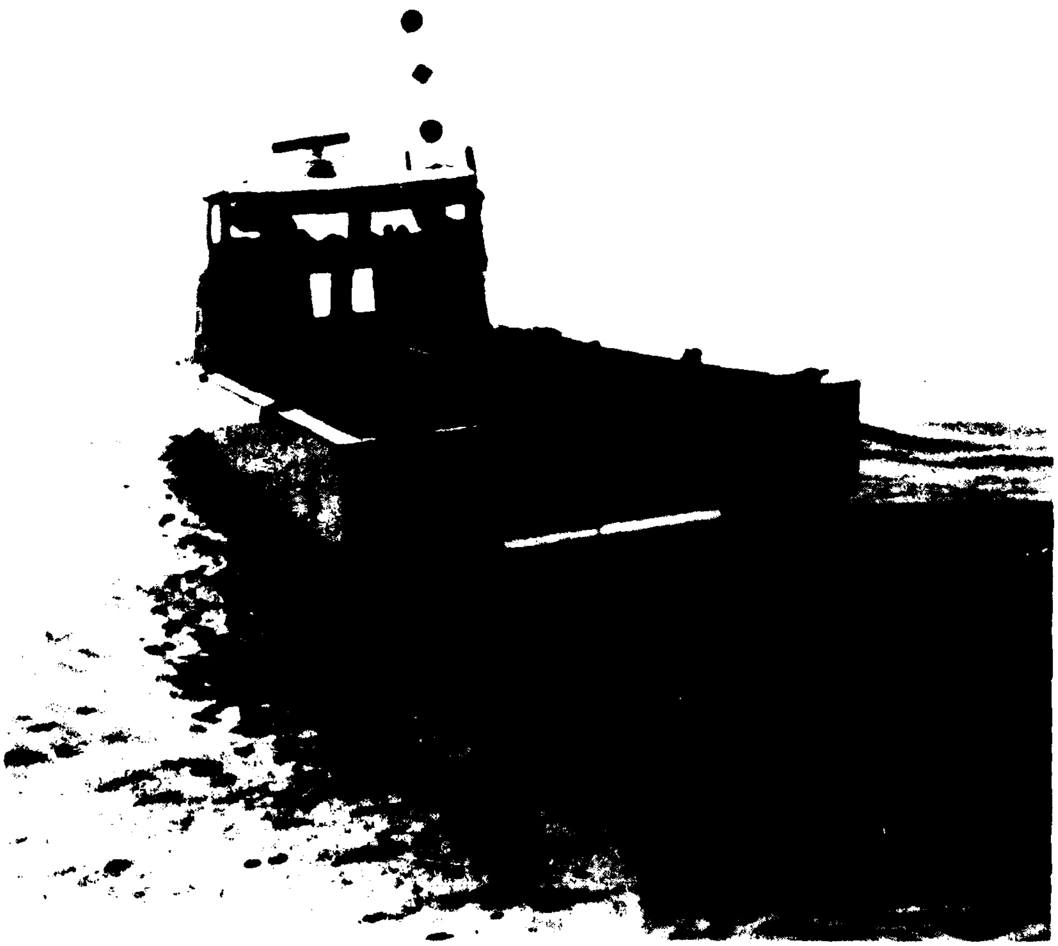

Figure 5. The 9-m Radon craft is shown here towing the large array. Chum can be seen running out of a pipe in the chum box on board.

Date	Array	Towing In	Times Out	Surface Temperature	Sharks Seen
8-20-82	large	0905	1035	20.8°C	yes
	thin	1043	1245		
8-26-82	thin	0852	1100	20.6°C	yes
	large	1110	1300		
9-02-82	large	0842	1030	21.1°C	yes
	thin	1040	1245		
9-09-82	thin	0837	1030	20.0°C	yes
	large	1040	1300		
9-15-82	large	0835	1030	20.0°C	no
	thin	1040	1240		
9-29-82	thin	1940	2330	20.0°C	no
10-06-82	thin	0830	1030	19.4°C	no
	large	1040	1230		
10-13-82	large	0820	1025	18.9°C	yes
	thin	1030	1230		
10-20-82	large	0830	1030	18.9°C	no
	thin	1035	1230		
10-27-82	thin	1830	2230	18.9°C	yes

Table 1. Trips to sea.

RESULTS

TASK A

The lemon shark had no difficulty in penetrating the thin array boot. As can be seen in figure 2a, the shark also severed some of the Kevlar strands molded into the boot. This shark was approximately 2.7 m long and weighed about 150 kg. The blue shark was about 2.4 m long and weighed approximately 75 kg. In this case, the shark did not bite completely through the boot, but only penetrated to the Kevlar strength cords (fig. 2b). We were unable to reproduce the long slashes observed on some of the damaged arrays (ref. 3).

In each case, the damage by the sharks' bites was probably less than one would expect under actual conditions of tow because the bites had to go through at least part of the fish fillets in order to reach the boot.

TASK B

The galvanic electric field generated by the titanium coupling in sea water was found to be small, but detectable by sharks. An average of the four measurements gave a dipole moment of 9.3 $\pm$3.7 μA cm. Assuming the field of the coupling to behave like an electric dipole, decreasing as the inverse cube of range, and the detection threshold for sharks to be 5×10^{-9} V/cm (ref. 4), the detection range was found to be 17 $\pm$2 cm.

TASK C

Each array was towed through a chummed area in the open sea for approximately 16 hr (see table 1) during daylight, and the thin array was towed an additional 8 hr in darkness. The towing depth at 4 knots was 2 to 3 m. The boots of both arrays had been drained of their oil and refilled with red-dyed sea water to facilitate detection of boot damage. No bites were detected on either array. Unfortunately, this part of the work could not be started until the third week in August when the local shark population was in its seasonal decline (ref. 6). This condition continued through the remaining tests.

Underwater observations of both arrays were made and photographs were taken. The metallic couplings of the thin array showed up very well (fig. 6), much more than would have been expected from observation of the array on the dock.

Due to its coating, the large array showed up better than the thin array because its contrasting plastic couplings showed up dark (fig. 7). The tape wrappings on the VIM of the large array were visually very prominent underwater (fig. 8).

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6. Johnson, C.S., Countermeasures to Shark Attack, in Handbook of Dangerous Animals for Field Personnel, Pickwell, G.V. and Evans, W.E., eds., NUC TP 324, December 1972.

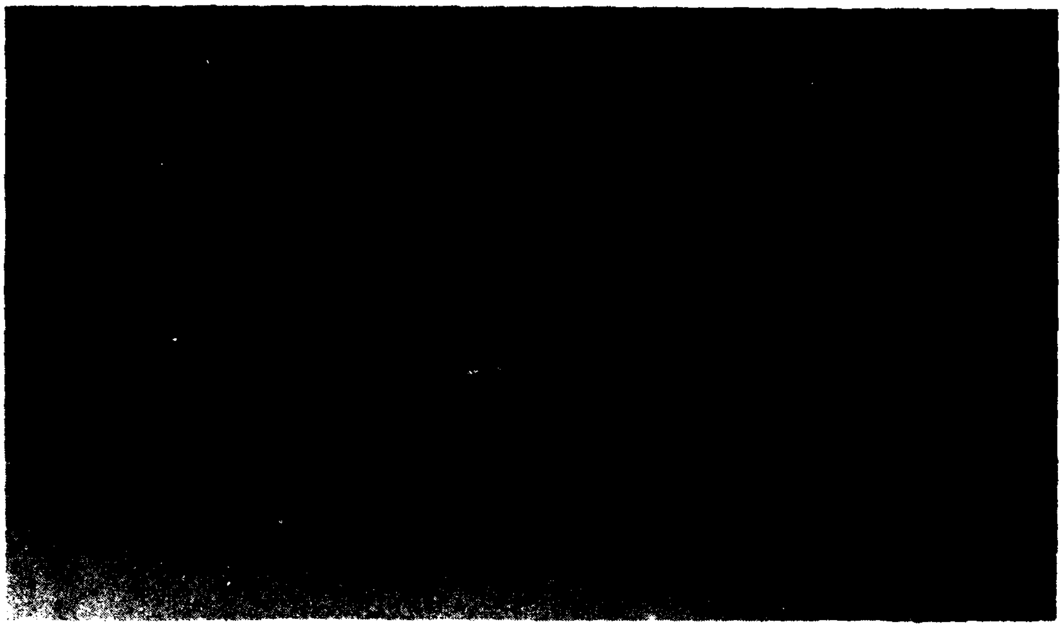


Figure 6. Underwater picture of the thin array shows the high visibility of the titanium coupling.

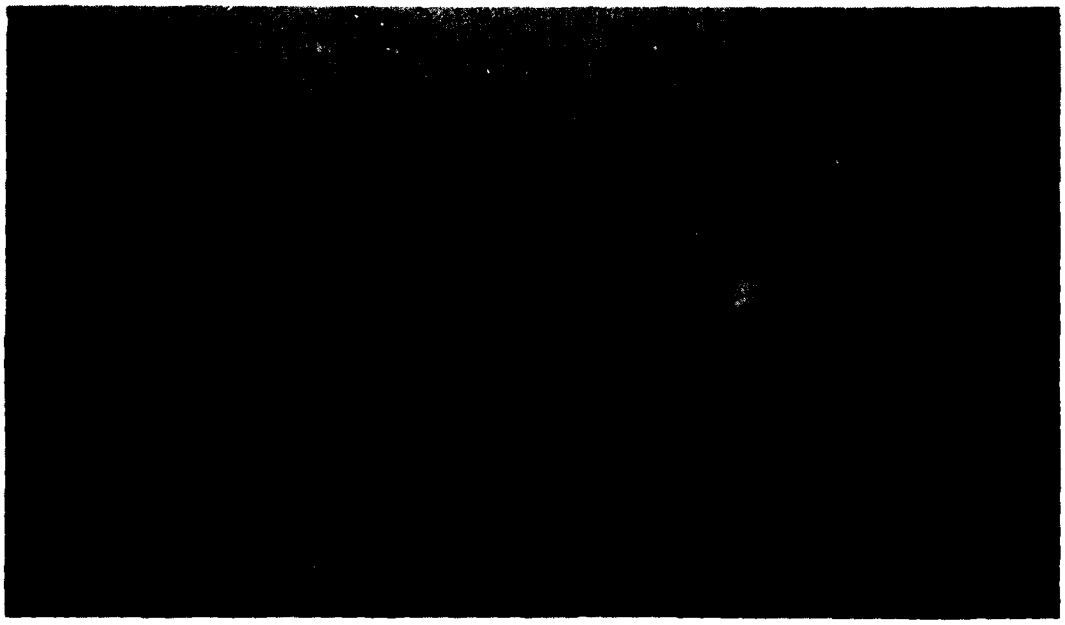


Figure 7. Picture of the large array underwater.

Figure 8. Underwater picture of the VIM of the large array shows the high visibility of the tape wrappings.

CONCLUSIONS

TASK A

A large lemon shark had no difficulty in penetrating the boot and Kevlar strength cords of the array. A smaller, less powerful blue shark only bit through the array boot, but did not sever the strength cords. We conclude from this that, if bitten by one of several species of large sharks (8 ft long or longer), the thin version of the BQR-15-array can be severely damaged.

TASK B

The galvanic field, measured around a titanium coupling from a thin array, is large enough to be detected by sharks at ranges less than 15 cm.

TASK C

While no bites were detected during this part of the work, underwater photographs of both arrays revealed parts that may attract sharks visually. The titanium couplings of the thin array appear shiny under water, and the tape wrappings on the VIM of the large array also show up prominently.

SUGGESTIONS FOR FURTHER WORK

Task C should be continued with continuous underwater observations of the arrays in the presence of sharks. Sharks make close approaches, and sometimes bump objects of interest. This occurs much more frequently than attacking and biting. From observations of this kind, parts of the arrays that are attractive to sharks can be determined and then countermeasures tested.

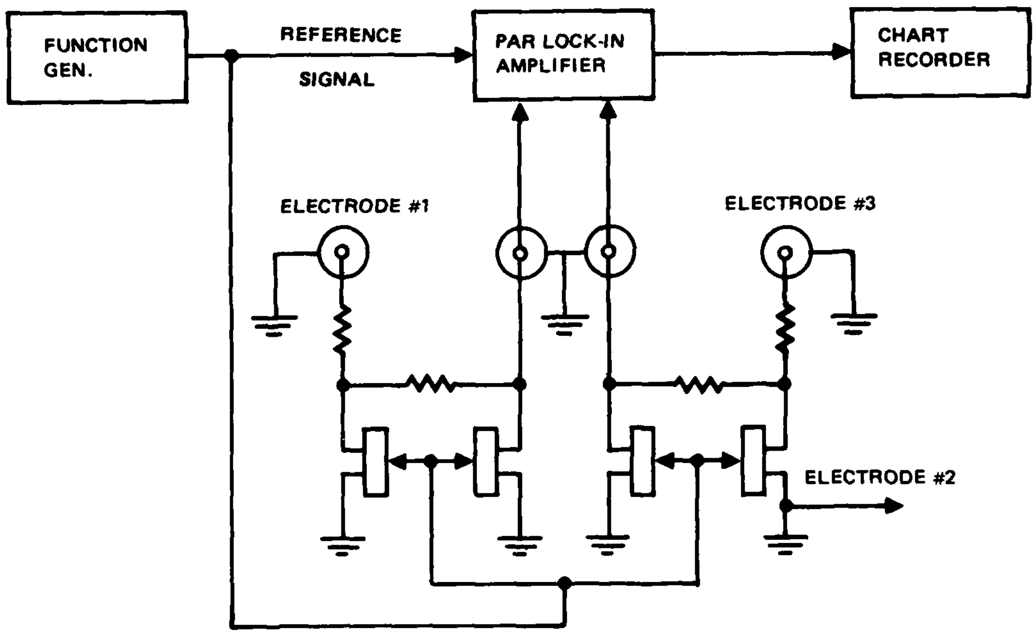
It would also be useful to test the feasibility of attracting sharks to invulnerable parts of the arrays by changing the visual appearance of the arrays. This will be important if other countermeasures are not effective.

APPENDIX

Figure A-1 shows the circuits used to measure the galvanic electric field of the thin array's titanium coupling. The center electrode (electrode 2) was connected to the ground shields of the coaxial cables and also connected as close as possible to electrodes 1 and 3 to reduce noise pickup.

In this arrangement, the function generator (Hewlett-Packard Model 3300A), operating with square wave output at 10 Hz, switches the Field Effect Transistors (FET) on for 50 ms and off for 50 ms. When the FETS are on, electrodes 1 and 3 are shorted to ground (electrode 2). When they are off, electrodes 1 and 3 are switched to the A and B inputs of the Princeton Applied Research (PAR) model HR-8 lock-in amplifier. This arrangement keeps the electrodes from drifting in potential, since they are shorted together half the time. It also allows the use of a lock-in amplifier to minimize external noise pickup.

Calibration of the system was accomplished by impressing a uniform electric field across the tank. To do this, salt bridge electrodes were evenly spaced across the ends of the tank, four at each end, and a constant current source generated the electric field. A 45V battery and large resistor were the constant current source. A current of 240 μA produced a field of 8.8 μV/cm in the tank. The current was switched on and off, and the voltage recorded on the Linear Instrument Corp. recorder, model 285/MM.



NOTES: 1. ALL RESISTORS ARE 12 kΩ
2. ALL FETs ARE 2N3819 P-TYPE FETs

Figure A-1. Circuit diagram of field-measuring electronics.

REFERENCES

1. Prindle, B., and Walden, R.G., Deep-Sea Lines Fishbite Manual, Woods Hole, Mass. 02543, 1975.

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6. Johnson, C.S., Countermeasures to Shark Attack, in Handbook of Dangerous Animals for Field Personnel, Pickwell, G.V. and Evans, W.E., eds., NUC TP 324, December 1972.

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