Woods Hole Oceanographic Institution

FIELD EXPERIMENTS ON ELECTRICALLY EVOKED FEEDING RESPONSES IN THE DOGFISH SHARK, *MUSTELUS CANIS*

by

Benjamin G. Dawson, Gail W. Heyer
René E. Eppi and Ad. J. Kalmijn

May 1981

TECHNICAL REPORT

Prepared for the Office of Naval Research under Contract N00014-79-C-0071.

Approved for public release, distribution unlimited.

WOODS HOLE, MASSACHUSETTS 02543

WHOI-81-38

FIELD EXPERIMENTS ON ELECTRICALLY EVOKED FEEDING RESPONSES IN THE DOGFISH SHARK, *MUSTELUS CANIS*

by

Benjamin G. Dawson, Gail W. Heyer,
René E. Eppi and Ad. J. Kalmijn

WOODS HOLE OCEANOGRAPHIC INSTITUTION
Woods Hole, Massachusetts 02543

May 1981

TECHNICAL REPORT

Prepared for the Office of Naval Research under Contract N00014-79-C-0071.

Approved for Distribution: George Grice, Chairman
Department of Biology

Reprinted from The Biological Bulletin, Vol. 159, No. 2, p. 482, October 1980
Printed in U. S. A.

Field experiments on electrically evoked feeding responses in the dogfish shark, Mustelus canis. BENJAMIN G. DAWSON, GAIL W. HEYER, RENÉ E. EPPI, AND AD. J. KALMIJN.

From previous laboratory experiments, we learned that sharks, skates, and rays have an electric sense that enables them to detect voltage gradients as low as 0.01 μV/cm within the frequency range from DC up to 8 Hz. The animals use their electric sense in predation, cuing in on the bioelectric fields commonly produced by fish and aquatic invertebrates. To quantify the response, we analyzed the feeding behavior of the shark *Mustelus canis* in Vineyard Sound off Cape Cod, Mass. An electrode panel was embedded in the ocean substrate in a water depth of 2–3 m. Two salt-bridge electrodes, simulating a small prey fish, were placed 2 cm apart at a distance of 15 cm from a centrally located odor source. Another pair of salt-bridge electrodes, simulating a larger fish, were placed 5 cm apart at a distance of 30 cm on the other side of the odor source. DC current of 8 μA was applied to either one or both pairs of electrodes. Observations were made at night from a Boston Whaler with a glass-bottomed observation well. Liquified herring chum attracted and motivated sharks. Markings on the electrode panel enabled observers to measure the distances from the electrodes at which the sharks initiated attacks. Data were recorded on the size of the sharks (30–40 cm pups or 90–120 cm adults), the vigor of response, and the pattern of attack. Out of 136 responses, first-year sharks attacked the 2-cm electrodes 49 times from a distance of 15 cm or more measured along the dipole axis, which corresponds to a sensitivity of 0.04 μV/cm or higher. Of these 49 responses, 16 were from at least 18 cm, yielding a sensitivity of 0.02 μV/cm or better. Out of 112 responses, larger sharks attacked the 5-cm electrodes 44 times from a distance of 30 cm or more, equivalent to 0.01 μV/cm or better. Of these 44 responses, 15 occurred from at least 38 cm measured along the dipole axis, establishing a sensitivity of 0.005 μV/cm or better. With both pairs of electrodes on, the small sharks, after attacking the 2-cm electrodes, often veered away from the 5-cm ones. In sum, the results support the conclusion that these sharks, once motivated by odor, rely heavily upon their keen electric sense in executing their final strikes.

(This work was conducted as part of Kalmijn's project on electric and magnetic detection under contract with the Office of Naval Research, N00014-79-C-0071.)

MANDATORY DISTRIBUTION LIST

FOR UNCLASSIFIED TECHNICAL REPORTS, REPRINTS, AND FINAL REPORTS
PUBLISHED BY OCEANOGRAPHIC CONTRACTORS
OF THE OCEAN SCIENCE AND TECHNOLOGY DIVISION
OF THE OFFICE OF NAVAL RESEARCH

(REVISED NOVEMBER 1978)

1 Deputy Under Secretary of Defense
(Research and Advanced Technology)
Military Assistant for Environmental Science
Room 3D129
Washington, D.C. 20301

Office of Naval Research
800 North Quincy Street
Arlington, VA 22217
3 ATTN: Code 483
1 ATTN: Code 460
2 ATTN: 102B

1 CDR J. C. Harlett, (USN)
ONR Representative
Woods Hole Oceanographic Inst.
Woods Hole, MA 02543

Commanding Officer
Naval Research Laboratory
Washington, D.C. 20375
6 ATTN: Library, Code 2627

12 Defense Documentation Center
Cameron Station
Alexandria, VA 22314
ATTN: DCA

Commander
Naval Oceanographic Office
NSTL Station
Bay St. Louis, MS 39522
1 ATTN: Code 8100
1 ATTN: Code 6000
1 ATTN: Code 3300

1 NODC/NOAA
Code D781
Wisconsin Avenue, N.W.
Washington, D.C. 20235

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: WHOI-81-38

2. GOVT ACCESSION NO.:

3. RECIPIENT'S CATALOG NUMBER:

4. TITLE *(and Subtitle)*: FIELD EXPERIMENTS ON ELECTRICALLY EVOKED FEEDING REPONSES IN THE DOGFISH SHARK, *MUSTELUS CANIS*

5. TYPE OF REPORT & PERIOD COVERED: Technical

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s): Benjamin G. Dawson, Gail W. Heyer, Rene E. Eppi, and Ad. J. Kalmijn

8. CONTRACT OR GRANT NUMBER(s): N00014-79-C-0071

9. PERFORMING ORGANIZATION NAME AND ADDRESS: Woods Hole Oceanographic Institution, Woods Hole, MA 02543

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:

11. CONTROLLING OFFICE NAME AND ADDRESS: NORDA/National Space Technology Laboratory, Bay St. Louis, MS 39529

12. REPORT DATE: May 1981

13. NUMBER OF PAGES:

14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*:

15. SECURITY CLASS. *(of this report)*: Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT *(of this Report)*: Approved for public release; distribution unlimited.

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

18. SUPPLEMENTARY NOTES: Reprinted from: The Biological Bulletin 159(2): 482 (October 1980).

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*:
1. Feeding responses
2. Electric sense
3. *Mustelus canis*

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

20.

From previous experiments, we learned that sharks, skates and rays have an electric sense that enables them to detect voltage gradients as low as 0.01 μV/cm within the frequency range from DC up to 8 Hz. The animals use their electric sense in predation, cuing in on the bioelectric fields commonly produced by fish and aquatic invertebrates. To quantify the response, we analyzed the feeding behavior of the shark *Mustelus canis* in Vineyard Sound off Cape Cod, Mass. An electrode panel was embedded in the ocean substrate in a water depth of 2-3 m. Two salt-bridge electrodes, simulating a small prey fish, were placed 2 cm apart at a distance of 15 cm from a centrally located odor source. Another pair of salt-bridge electrodes, simulating a larger fish, were placed 5 cm apart at a distance of 30 cm on the other side of the odor source. DC current of 8 μA was applied to either one or both pairs of electrodes. Observations were made at night from a Boston Whaler with a glass bottomed observation well. Liquefied herring chum attracted and motivated sharks.

In sum, theresults support the conclusion that these sharks, once motivated by odor rely heavily upon their keen electric sense in executing their final strikes.

Woods Hole Oceanographic Institution
WHOI-81-38

FIELD EXPERIMENTS ON ELECTRICALLY EVOKED FEEDING RESPONSES IN THE DOGFISH SHARK, *MUSTELUS CANIS* by Benjamin G. Dawson, Gail W. Heyer, Rene E. Eppi and Ad. J. Kalmijn. May 1981. Prepared for the Office of Naval Research under Contract N00014-79-C-0071.

From previous laboratory experiments, we learned that sharks, skates, and rays have an electric sense that enables them to detect voltage gradients as low as 0.01 μV/cm within the frequency range from DC up to 8 Hz. The animals use their electric sense in predation, cuing in on the bioelectric fields commonly produced by fish and aquatic invertebrates. To quantify the response, we analyzed the feeding behavior of the shark *Mustelus canis* in Vineyard Sound off Cape Cod, Mass. An electrode panel was embedded in the ocean substrate in a water depth of 2-3 m. Two salt-bridge electrodes, simulating a small prey fish, were placed 2 cm apart at a distance of 15 cm from a centrally located odor source. Another pair of salt-bridge electrodes, simulating a larger fish, were placed 5 cm apart at a distance of 30 cm on the other side of the odor source. DC current of 8 μA was applied to either one or both pairs of electrodes. Observations were made at night from a Boston Whaler with a glass-bottomed observation well. Liquefied herring chum attracted and motivated sharks.

In sum, the results support the conclusion that these sharks, once motivated by odor rely heavily upon their keen electric sense in executing their final strikes.

1. Feeding reponses
2. Electric sense
3. *Mustelus canis*

I. Dawson, Benjamin G.
II. Heyer, Gail W.
III. Eppi. Rene E.
IV. Kalmijn, Ad. J.
V. N00014-79-C-0071

This card is UNCLASSIFIED

Woods Hole Oceanographic Institution
WHOI-81-38

FIELD EXPERIMENTS ON ELECTRICALLY EVOKED FEEDING RESPONSES IN THE DOGFISH SHARK, *MUSTELUS CANIS* by Benjamin G. Dawson, Gail W. Heyer, Rene E. Eppi and Ad. J. Kalmijn. May 1981. Prepared for the Office of Naval Research under Contract N00014-79-C-0071.

From previous laboratory experiments, we learned that sharks, skates, and rays have an electric sense that enables them to detect voltage gradients as low as 0.01 μV/cm within the frequency range from DC up to 8 Hz. The animals use their electric sense in predation, cuing in on the bioelectric fields commonly produced by fish and aquatic invertebrates. To quantify the response, we analyzed the feeding behavior of the shark *Mustelus canis* in Vineyard Sound off Cape Cod, Mass. An electrode panel was embedded in the ocean substrate in a water depth of 2-3 m. Two salt-bridge electrodes, simulating a small prey fish, were placed 2 cm apart at a distance of 15 cm from a centrally located odor source. Another pair of salt-bridge electrodes, simulating a larger fish, were placed 5 cm apart at a distance of 30 cm on the other side of the odor source. DC current of 8 μA was applied to either one or both pairs of electrodes. Observations were made at night from a Boston Whaler with a glass-bottomed observation well. Liquefied herring chum attracted and motivated sharks.

In sum, the results support the conclusion that these sharks, once motivated by odor rely heavily upon their keen electric sense in executing their final strikes.

1. Feeding reponses
2. Electric sense
3. *Mustelus canis*

I. Dawson, Benjamin G.
II. Heyer, Gail W.
III. Eppi. Rene E.
IV. Kalmijn, Ad. J.
V. N00014-79-C-0071

This card is UNCLASSIFIED

Woods Hole Oceanographic Institution
WHOI-81-38

FIELD EXPERIMENTS ON ELECTRICALLY EVOKED FEEDING RESPONSES IN THE DOGFISH SHARK, *MUSTELUS CANIS* by Benjamin G. Dawson, Gail W. Heyer, Rene E. Eppi and Ad. J. Kalmijn. May 1981. Prepared for the Office of Naval Research under Contract N00014-79-C-0071.

From previous laboratory experiments, we learned that sharks, skates, and rays have an electric sense that enables them to detect voltage gradients as low as 0.01 μV/cm within the frequency range from DC up to 8 Hz. The animals use their electric sense in predation, cuing in on the bioelectric fields commonly produced by fish and aquatic invertebrates. To quantify the response, we analyzed the feeding behavior of the shark *Mustelus canis* in Vineyard Sound off Cape Cod, Mass. An electrode panel was embedded in the ocean substrate in a water depth of 2-3 m. Two salt-bridge electrodes, simulating a small prey fish, were placed 2 cm apart at a distance of 15 cm from a centrally located odor source. Another pair of salt-bridge electrodes, simulating a larger fish, were placed 5 cm apart at a distance of 30 cm on the other side of the odor source. DC current of 8 μA was applied to either one or both pairs of electrodes. Observations were made at night from a Boston Whaler with a glass-bottomed observation well. Liquefied herring chum attracted and motivated sharks.

In sum, the results support the conclusion that these sharks, once motivated by odor rely heavily upon their keen electric sense in executing their final strikes.

1. Feeding reponses
2. Electric sense
3. *Mustelus canis*

I. Dawson, Benjamin G.
II. Heyer, Gail W.
III. Eppi. Rene E.
IV. Kalmijn, Ad. J.
V. N00014-79-C-0071

This card is UNCLASSIFIED

Woods Hole Oceanographic Institution
WHOI-81-38

FIELD EXPERIMENTS ON ELECTRICALLY EVOKED FEEDING RESPONSES IN THE DOGFISH SHARK, *MUSTELUS CANIS* by Benjamin G. Dawson, Gail W. Heyer, Rene E. Eppi and Ad. J. Kalmijn. May 1981. Prepared for the Office of Naval Research under Contract N00014-79-C-0071.

From previous laboratory experiments, we learned that sharks, skates, and rays have an electric sense that enables them to detect voltage gradients as low as 0.01 μV/cm within the frequency range from DC up to 8 Hz. The animals use their electric sense in predation, cuing in on the bioelectric fields commonly produced by fish and aquatic invertebrates. To quantify the response, we analyzed the feeding behavior of the shark *Mustelus canis* in Vineyard Sound off Cape Cod, Mass. An electrode panel was embedded in the ocean substrate in a water depth of 2-3 m. Two salt-bridge electrodes, simulating a small prey fish, were placed 2 cm apart at a distance of 15 cm from a centrally located odor source. Another pair of salt-bridge electrodes, simulating a larger fish, were placed 5 cm apart at a distance of 30 cm on the other side of the odor source. DC current of 8 μA was applied to either one or both pairs of electrodes. Observations were made at night from a Boston Whaler with a glass-bottomed observation well. Liquefied herring chum attracted and motivated sharks.

In sum, the results support the conclusion that these sharks, once motivated by odor rely heavily upon their keen electric sense in executing their final strikes.

1. Feeding reponses
2. Electric sense
3. *Mustelus canis*

I. Dawson, Benjamin G.
II. Heyer, Gail W.
III. Eppi. Rene E.
IV. Kalmijn, Ad. J.
V. N00014-79-C-0071

This card is UNCLASSIFIED