SHARKBANZ

MAGNETIC TECHNOLOGY RESEARCH & CLAIMS - 2018

MAGNETIC REPELLENT TECHNOLOGY PATENT

Via Mano LLC's exclusive licensing agreement with scientific partner, SharkDefense Technologies LLC, Mano LLC has full and exclusive commercial usage rights of:

United States Patent – 9,084,415

"Devices and methods are disclosed for repelling elasmobranchs with high-pull-force magnets, including devices and methods for reducing by-catch in commercial fisheries and protecting humans from attacks by elasmobranchs."

<*US Patent Link*>

Australia Patent – AU2006223291

**This technology has additional international patent territories (Pending).*

SHARKBANZ SCIENTIFIC PARTNERSHIP

SharkDefense Technologies LLC - History

SharkDefense was founded in September 2001 by Eric and Jean Stroud. Its early work sought to research the existence of trace chemical messengers in elasmobranchs and to develop a series of highly selective chemical shark repellents using state-of-the-art analytical and synthesis techniques. Many successes in this initial research effort have led to new discoveries in shark repellent technologies, particularly for bycatch reduction.

SharkDefense Technologies LLC is a scientific research and development company, an SAM vendor, and is in good standing in the state of New Jersey, USA.

SharkDefense - Mission Statement

"SharkDefense Technologies LLC is the leading researcher of chemical, electrochemical, and magnetic shark repellents. Its primary mission is to research and develop shark bycatch reduction devices. Its secondary mission is to research and develop shark repellents for rescue operations, aquaculture, and alternatives to shark netting."

SharkDefense - Animal Humanity

Great care is taken to ensure that our test specimens, both captive and wild, are not harmed during our research. This means that we follow IACUC procedures in the United States and that we hold Bahamian research permits and a collection permit for tests in the Bahamas.

The SharkDefense team works closely with Florida Keys Community College, Seton Hall University, Dr. Samuel Gruber, and the Bimini Biological Field Station.

SharkDefense - Team Members

DR. PATRICK H. RICE – Partner and Sr. Marine Biologist, Director of Marine Sciences, FKCC

COMMITTEES:

- Advisory Board Member, Wyland Foundation (http://www.wylandfoundation.org/index.php)
- Chair, Science/Technology Taskforce. Florida Keys Environmental Coalition (2010).
- Administrative Representative, Florida Keys Community College Educational Foundation (2010)

CERTIFICATIONS:

- Certificate in Aquacultural Science (1994) Asian Institute of Technology, Bangkok, Thailand
- Certificate in Aquacultural Extension (1995) Food & Agriculture Organization of the United Nations, University of the South Pacific, Suva, Fiji

SCUBA:

- American Academy of Underwater Sciences – Scientific Diver
- NOAA NITROX
- Cavern Diver
- NAUI Master Diver
- NAUI Advanced Open Water
- PADI Open Water

FELLOWSHIPS:

- National Science Foundation/Monbusho Research Experience Fellowships for Young Foreign Researchers (1999). Kagoshima University, Kagoshima-shi, Japan (Japanese Mariculture).

DR. ERIC M. STROUD – Managing Partner and Sr. Chemist

Eric Stroud is an entrepreneurial organist chemist, life sciences consultant, and a co-founder of SharkDefense. In his career, he has developed a variety of chemical, cosmetic, and medical device products for clients. His research interests include chemical alarm signals, repellents, Schreckstoffs, magnetoreception, and time-release delivery. He is a general class amateur radio operator (N2GHZ), and enjoys beekeeping.

AWARDS:

2013 – Seton Hall University Petersheim Award, most outstanding graduate student.

2011 – New Jersey Inventor's Hall of Fame, Graduate Student Award.

2006. WWF Smartgear Competition. Grand Prize (SharkDefense, submitted under partner's name Michael Herrmann). "DETERRING SHARKS WITH MAGNETS".

COMPETITIVE GRANTS:

2013. Save our Seas Foundation. SMART Circle Hooks for Shark Bycatch Reduction.

2012. NOAA Bycatch Reduction and Engineering Program (BREP)

2010. Great Lakes Fishery Commission. Development of a Putrefaction-Derived Repellent for the Sea Lamprey.

2010. National Science Foundation. Small Business Innovative Research Phase 1B Award (SBIR). "Multifunctional Hook Material for Commercial Fisheries".

2010. National Science Foundation. Small Business Innovative Research Phase 1 Award (SBIR). "Multifunctional Hook Material for Commercial Fisheries".

2010. Michigan State University, Center for Water Sciences Venture Grant. "Preliminary identification of a putrefaction-derived repellent for the invasive sea lamprey (Petromyzon marinus)".

2009. Saltonstall-Kennedy Grant Program, FY 2009. "Process for Converting Shark Discards into a Shark Bycatch Reduction Technology".

2005. NOAA PIFSC/JIMAR, Hawaii. Chemical repellents as a means to reduce shark bycatch in commercial longlines.

2005. NOAA PIFSC/JIMAR, Hawaii. Equipment/capital grant for chemical repellent research.

DR. JAMES E. HANSEN – Visiting scholar

Dr. James Hansen, formerly Director of the NASA Goddard Institute for Space Studies, is Adjunct Professor at Columbia University's Earth Institute, where he directs a program in Climate Science, Awareness and Solutions.. Dr. Hansen is best known for his testimony on climate change in the 1980s that helped raise awareness of global warming. He is a member of the U.S. National Academy of Sciences and has received numerous awards including the Sophie and Blue Planet Prizes. Dr. Hansen is recognized for speaking truth to power and for outlining actions needed to protect the future of young people and all species on the planet.
– Columbia University Earth Institute, Climate Science, Awareness and Solutions

BRIAN DeSANTI II - Associate Marine Biologist

Brian DeSanti holds a Bachelor's degree in Marine Science from Florida Gulf Coast University. He has recently finished his Master's degree in Biological Oceanography from Florida State University, where his studies were focused on deep-sea corals and benthic ecology. He is currently working as a Marine Research Assistant and Adjunct Professor at the Florida Keys Community College.

SharkDefense - Associates

- **Dr. Samuel Gruber** – University of Miami RSMAS, Founder, Bimini Biological Field Station, Founder, AES
- **Alan Chiesa** – Specimen collection

SharkDefense - Research Partners

- Florida Keys Community College
- Bimini Biological Field Station
- Bimini Sands Bahamas
- Michigan State University
- Wagner Research Group
- Marathon Aquaranch and Symbiologics

SharkDefense - Contact Information

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Dr. Patrick H. Rice - Sr. Marine Biologist Director of Marine Sciences, FKCC
Email: pat@sharkdefense.com

Dr. Eric M. Stroud – Sr. Chemist
Email: eric@sharkdefense.com

MAGNETIC SHARK REPELLENT OVERVIEW

Introduction

Several species of sharks have demonstrated the ability to sense magnetic fields. (Kalmijn, 1978; Ryan, 1980; Klimley, 1993; 2002). The Ampullae of Lorenzini organ within sharks is used to detect weak electrical fields at short ranges. The detection range of this organ is effective only within inches, as sharks sense bioelectrical fields in the final stages of prey capture. SharkDefense has found that flux per unit area of certain permanent magnets, particularly Neodymium-Iron-Boride and Barium-Ferrite magnets, corresponds closely with the detection range of the Ampullae of Lorenzini. A permanent magnet with the correct specifications is hypotheiszed to over-stimulate the Ampullae of Lorenzini, and may therefore be used as selective shark repellent.

The ampullae of Lorenzini are small vesicles and pores that form part of a subcutaneous sensory network of sharks. These vesicles and pores are found around the head of the shark and are visible to the naked eye. They appear as dark spots in this photograph of a porbeagle shark head. (Photo: Dr. Steven Campana, Bedford Institute of Oceanography)

The fields generated by these permanent magnets (shown above) decreases at the inverse cube of the distance from the magnet to sharks and rays. Therefore, at distances of a few meters from the magnet, the field exerted is less than the Earth's magnetic field. Animals which lack that Ampullae of Lorenzini organ do not display aversive behavior in close proximity to the magnetic field, making this technology selective

Overview of Magnetoreception

There are several theories on the sensory mechanisms responsible for magnetoreception, including magnetite based magnetoreception and indirect magnetoreception by electroreception during electromagnetic induction.

Currently, the most commonly accepted theory on magnetite based magnetoreception involves thousands of small magnetic crystals (magnetite, $Fe2O3$) linked to the phospholipid bilayer of neurons via glycoproteins (Figure 1).

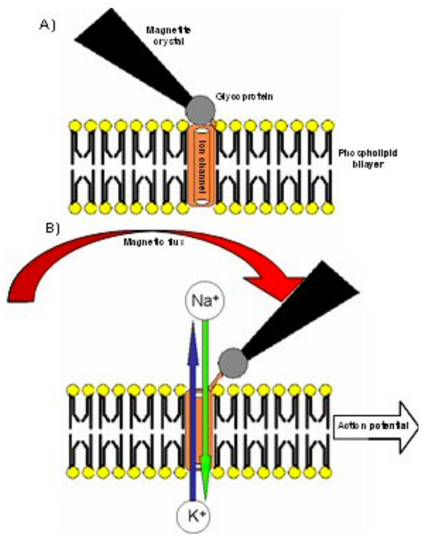


Figure 1

The glycoproteins act as small stoppers on ion channels when the ambient magnetic field orients the magnetite in such a way as to block the ion channel. When a migratory animal moves through the earth's magnetic field, the magnetite reorients allowing free flow of ions across the phospholipids bilayer generating an action potential which transmits geolocation information to the brain for processing. Magnetite based magnetoreception has been reported for many migratory marine species including yellowfin tuna (Walker et al. 1982), rainbow trout (Diebel et al. 2000), sea turtles (Lohmann et al. 2001) and spiny lobster (Boles and Lohmann 2003).

Elasmobranch fishes (sharks, skates and rays) have demonstrated the ability detect the earth's magnetic field, although the mechanism remains undescribed (Lohmann and Johnsen 2000). Indirect magnetoreception via electromagnetic induction is currently the most widely accepted mechanism, although magnetite based magnetoreception and chemical magnetoreception remain potential explanations.

Illustration of a potential mechanism for magnetite-based magnetoreception involving changes in magnetite orientation in the presence of magnetic flux. The magnetic torque on the magnetite crystal removes the glycoprotein from the ion channel allowing ion exchange across the nervous membrane and generating an action potential (i.e., nervous signal) carrying the information to the brain for processing.

Elasmobranchs have a unique sensory adaptation that allows them to detect electric fields in the marine environment. This sensory ability is referred to as electroreception and the sensory organ associated with electroreception is the Ampullae of Lorenzini. The ampullae are gel-filled pores homogenously distributed around the nose and mouth. The sensory system is designed to detect weak electric fields generated by mechanical muscle movement (e.g., swimming muscles or a beating heart). In the presents of an electric field, the electric potential at the surface of the animal will vary from the electric potential of the interior of the animal. This potential difference is then detected by the sensory cells that line the ampullae. Once the voltage differential is recognized, the sensory information is transmitted to the brain via afferent neurons (Adair et al. 1998).

Electromagnetic Induction

When a shark swims through the earth's magnetic field, electromagnetic induction – phenomena which generates an electric field as charged particles move through a magnetic field – creates an electric field around the shark (Figure 2).

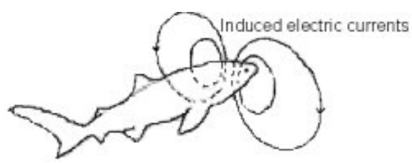


Figure 2

Minute differences in the earth's magnetic field at different locations result in minute differences in the induced electric field which may be detected by the shark's sensitive electroreceptors, especially as the head region moves back and forth during swimming (Lohmann and Johnsen 2000).

The law of electromagnetic induction (Faraday's Law) states that induced electromotive force (EMF) is proportional to the rate of change of the magnetic flux through a coil (an electric current can also be produced within a conductor when the conductor is moved through a magnetic field). This occurs because the force generated by the magnetic lines is applying a force on the free electrons in the conductor, causing the electrons to move. We hypothesize that the shark's body (particularly its Ampullae of Lorenzini) acts as the conductor moving through the Earth's magnetic field or the permanent magnet's field, registering the induced EMF.

SharkDefense Research and Technologies

After being rewarded the grand prize at the 2006 Smart Gear Competition, members of SharkDefense have conducted extensive testing on the effectiveness of Grade C8 Barium Ferrite ($BaFe2O4$) permanent magnets as an elasmobranch-selective repellent.

Under the supervision of Dr. Samuel H. Gruber, SharkDefense Technologies LLC has conducted numerous experiments using the facilities at the Bimini Biological Field Station, Bimini, Bahamas.

Our preliminary experimental analyses began with the development of a magnetic maze (Figure 3). For this study, we buried permanent magnets just beneath the substrate in a maze-like pattern within a circular pen. Nurse sharks (Ginglymostoma cirratum) and southern stingrays (Dasyatis americana) had to complete the maze to utilize the remaining portions of the pen. This experiment demonstrated that the swimming behavior of D. americana and G. cirratum could be manipulated with the use of ceramic magnets.

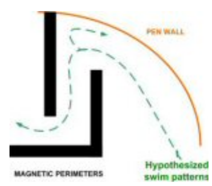


Figure 3

Secondly, SharkDefense Technologies LLC is conducting a study where the swimming behavior of juvenile lemon sharks (Negaprion brevirostris) is being observed within a circular pen containing a construction-mesh barrier. This barrier was constructed along the diameter of the circular pen and contained two 0.25 m2 openings on either end of the fence. The magnetic opening (treatment) was surrounded by four C8 Barium Ferrite ($BaFe2O4$) permanent magnets which measured approximately 400 Gauss at the surface. The control opening was surrounded by four clay bricks of similar size and shape to the magnetic treatment with no measurable magnetic field (Figure 4). The sharks were encouraged to swim from one side of the pen to the other by introducing fish juice (blood, fish oil, etc.) into the region of the pen opposite the sharks. Results indicated that N. brevirostris detected and were sensitive to the magnetic flux and avoided the magnetic treatment while swimming through the control a greater number of times. The sharks demonstrated greater avoidance behavior (i.e. accelerations away from, 90 or 180 degree turns) to the region containing permanent magnets when compared to the controls.

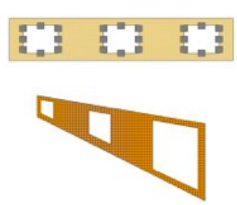
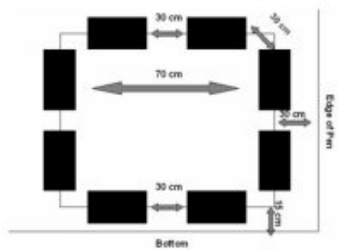


Figure 4
A selective shark-repellent fence designed by SharkDefense Technologies LLC. Openings are large enough to accommodate seals, turtles, and large fish.

These data suggest that a selective shark exclusion magnetic barrier, in addition to the shark-nets on human populated beaches, may reduce elasmobranch mortality associated with shark-nets. Shark nets are used to prevent the entrance of sharks to areas where bathers frequent. These nets usually contain mesh holes 50 cm wide which are small enough to entangle the larger sharks, while allowing smaller fish to pass through. The only problem with this development is that not only are shark populations being decimated, but batoids and a variety of marine mammals are being killed within these nets (Dudley & Cliff, 1992).



Detail of an opening in the fence. Permanent magnets are secured around the perimeter of the opening to selectively exclude elasmobranchs.

Alternatively, in the Northwestern Hawaiian Islands, the endangered monk seal (Monachus schauinslandi) populations are at predation risk by the Galapagos shark (Carcharhinus galapagensis). These sharks are prowling the nesting areas of these seals, where they prey upon the adults and pup monk seals as they enter the water in search of food. This has become an urgent issue and we believe that we could reduce the amount of shark on seal interaction by utilizing this idea of a magnetic fence design.

A selective shark-repellent fence designed by SharkDefense Technologies LLC. Openings are large enough to accommodate seals, turtles, and large fish.

Detail of an opening in the fence. Permanent magnets are secured around the perimeter of the opening to selectively exclude elasmobranchs.

Finally, our Craig O'Connell completed his Master's Thesis on the effectiveness of permanent magnets on the feeding and swimming behavior of elasmobranchs at Coastal Carolina University. In January 2010, Craig's research was accepted for publication. Continuing work examining the effectiveness of magnets on fishing gear has been explored using rod and reel techniques. The data obtained from this study demonstrated that elasmobranchs favor hooks that do not contain magnets suggesting that the application of magnets on longlines could have a significant impact on reducing elasmobranch bycatch on longlines.

Detail of a rare earth magnet secured on a longline gangion.

TECHNOLOGY RESEARCH TESTING ARTICLES

Great White Sharks

Effects of the Sharksafe barrier on white shark (Carcharodon carcharias) behavior and its implications for future conservation technologies

Craig P. O’Connell · Sara Andreotti · Michael Rutzen · Michael Meÿer · Conrad A. Matthee · Pingguo He
[Show abstract]
Journal of Experimental Marine Biology and Ecology 11/2014; 460:37–46. DOI:10.1016/j.jembe.2014.06.004 · 1.87 Impact Factor

The use of permanent magnets to reduce elasmobranch encounter with a simulated beach net. 2. The great white shark (Carcharodon carcharias)

Craig P. O'Connell · Sara Andreotti · Michael Rutzen · Michael Meyer · Pingguo He
[Show abstract]
Ocean & Coastal Management 11/2012; 97. DOI:10.1016/j.ocecoaman.2012.11.006 · 1.75 Impact Factor

Bull Sharks

The use of permanent magnets to reduce elasmobranch encounter with a simulated beach net. 1. The bull shark (Carcharhinus leucas)

Craig P. O'Connell · Saang-Yoon Hyun · Samuel H. Gruber · Timmy J. O'Connell · Grant Johnson · Katie Grudecki · Pingguo He
[Show abstract]
Ocean & Coastal Management 08/2014; 97. DOI:10.1016/j.ocecoaman.2013.12.012 · 1.75 Impact Factor

Galapagos Sharks:

Assessment of permanent magnets and electropositive metals to reduce the line-based capture of Galapagos sharks,
Carcharhinus galapagensis.
W.D. Robbins, V.M. Peddemors, S.J. Kennelly. Fisheries Research 109 (2011) 100–106.

Australian Species

Do elasmobranch reaction to magnetic fields in water show promise for bycatch mitigation?
Rigg, D.P., Peverell, S.C., Hearndon, M., Seymour, J.E., (2009). Marine and Freshwater Research 60, 942-948

Lemon Sharks:

Behavioral modification of visually deprived lemon sharks (Negaprion brevirostris) towards magnetic fields

C.P. O'Connell · T.L. Guttridge · S.H. Gruber · J. Brooks · J.S. Finger · P. He
[Show abstract]
Journal of Experimental Marine Biology and Ecology 04/2014; 453:131–137. DOI:10.1016/j.jembe.2014.01.009 · 1.87 Impact Factor

Response of juvenile lemon sharks, Negaprion brevirostris, to a magnetic barrier simulating a beach net

Craig P. O'Connell · Daniel C. Abel · Samuel H. Gruber · Eric M. Stroud · Patrick H. Rice
[Show abstract]
Ocean & Coastal Management 03/2011; 54(3):225-230. DOI:10.1016/j.ocecoaman.2010.11.006 · 1.75 Impact Factor

Great Hammerhead Sharks:

The effects of barium-ferrite permanent magnets on great hammerhead shark Sphyrna mokarran behavior and implications for future conservation engineering technologies

Craig P. O'Connell
Endangered Species Research 06/2014; · 2.26 Impact Factor

Catsharks:

The effects of neodymium-iron-boron permanent magnets on the behaviour of the small spotted catshark (Scyliorhinus canicula) and the thornback skate (Raja clavata)

Lauren E. Smith · Craig P. O'Connell
[Show abstract]
Ocean & Coastal Management 07/2013; 97. DOI:10.1016/j.ocecoaman.2013.05.010 · 1.75 Impact Factor

Stingrays:

Responses of the southern stingray (Dasyatis americana) and the nurse shark (Ginglymostoma cirratum) to permanent magnets

Craig P. O'Connell · Daniel C. Abel · Patrick H. Rice · Eric M. Stroud · Nicole C. Simuro
[Show abstract]
Marine and Freshwater Behaviour and Physiology 01/2010; 43(1):63-73. DOI: 10.1080/10236241003672230 · 0.92 Impact Factor

Spiny Dogfish:

Effects of the SMART (TM) (Selective Magnetic and Repellent-Treated) hook on spiny dogfish catch in a longline experiment in the Gulf of Maine

Craig P. O'Connell · PIngguo He · Jason Joyce · Eric M. Stroud · Patrick H. Rice
[Show abstract]

Ocean & Coastal Management 08/2012; 97. DOI:10.1016/j.ocecoaman.2012.08.002 · 1.75 Impact Factor

Commercial and Recreational Fishing:

Analysis of permanent magnets as elasmobranch bycatch reduction devices in hook-and-line and longline trials

C.P. O'Connell · D.C. Abel · E.M. Stroud · P.H. Rice

Analysis of permanent magnets as elasmobranch bycatch reduction devices in hook-and-line and longline trials

Craig P. O'Connell · Daniel C. Abel · Patrick H. Rice · Eric M. Stroud
[Show abstract]
Fisheries Research 10/2011; 109(4):394. · 1.90 Impact Factor

Special Issues and Large Studies

SPECIAL ISSUE: SHARK DEFENSE

Victor N. de Jonge · Craig O'Connell
Ocean & Coastal Management 08/2014; 97:1-1. DOI:10.1016/j.ocecoaman.2014.05.021 · 1.75 Impact Factor

The emerging field of electrosensory and semiochemical shark repellents: Mechanisms of detection, overview of past studies, and future directions

Craig P. O'Connell · Eric M. Stroud · Pingguo He
[Show abstract]
Ocean & Coastal Management 11/2012; 97. DOI:10.1016/j.ocecoaman.2012.11.005 · 1.75 Impact Factor

A large scale field analysis examining the effect of magnetically-treated baits and barriers on teleost and elasmobranch behavior

C.P. O'Connell · P. He
[Show abstract]
Ocean & Coastal Management 08/2014; 96:130-137. DOI:10.1016/j.ocecoaman.2014.05.011 · 1.75 Impact Factor

NOAA Technical Memorandum NMFS-PIFSC-16
Swimmer, Y, J. H. Wang, and L. McNaughton. 2008. Shark deterrent and incidental capture workshop, April 10–11, 2008. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-PIFSC-16, 72 p.

Other Awards / References

Smartgear (2012)
<*http://www.smartgear.org/smartgear_winners/smartgear_winner_2006/smartgear_winner_2006grand/*> Date: 15/02/2013

Jezek, G. (2013).
<*www.howmagnetswork.com*>