

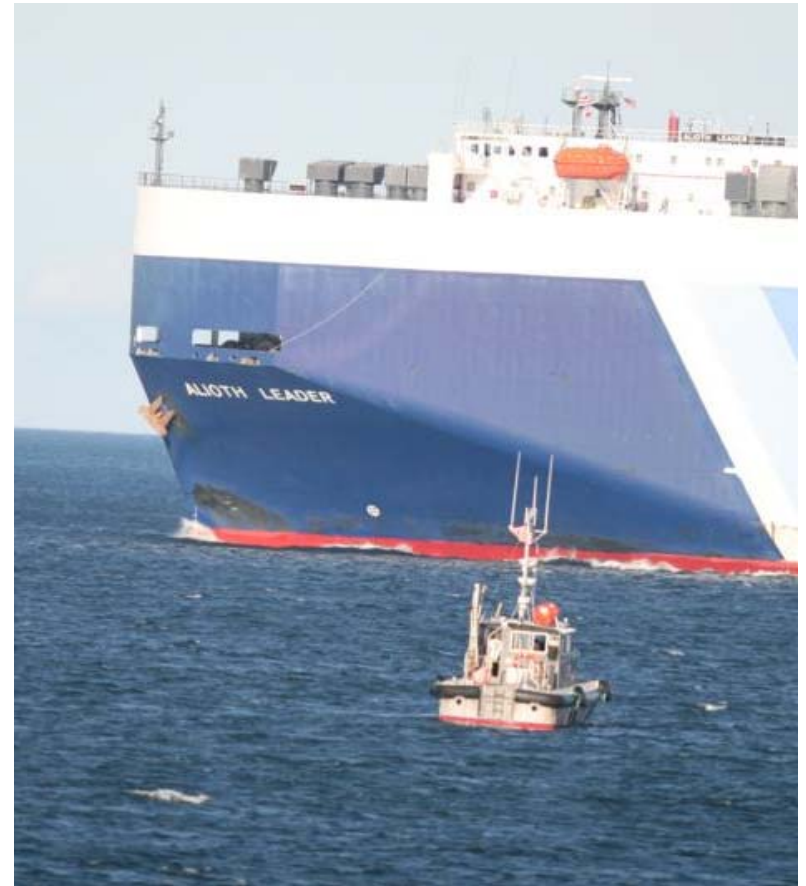
# **RI Wind Farm Siting Study- Acoustic Noise and Electromagnetic Effects**

**Presentation to Stakeholder Meeting:  
April 7, 2009**

Principal Investigator: James H. Miller, Ocean Engineering  
Associate Investigators: Gopu Potty, Ocean Engineering and  
Kathleen Vigness-Raposa, Office of Marine Programs

# Objectives

- Perform a detailed analysis of the atmospheric noise conditions and underwater noise conditions presently existing in the candidate locations.
- Predict the atmospheric noise and underwater noise levels during and after construction of the wind facility in the candidate locations.
- Estimate the effects of the added noise on marine mammals, fish, turtles, and other animals native to the region.



M/V Alioth Leader (Rod Smith)

# Objectives (cont.)

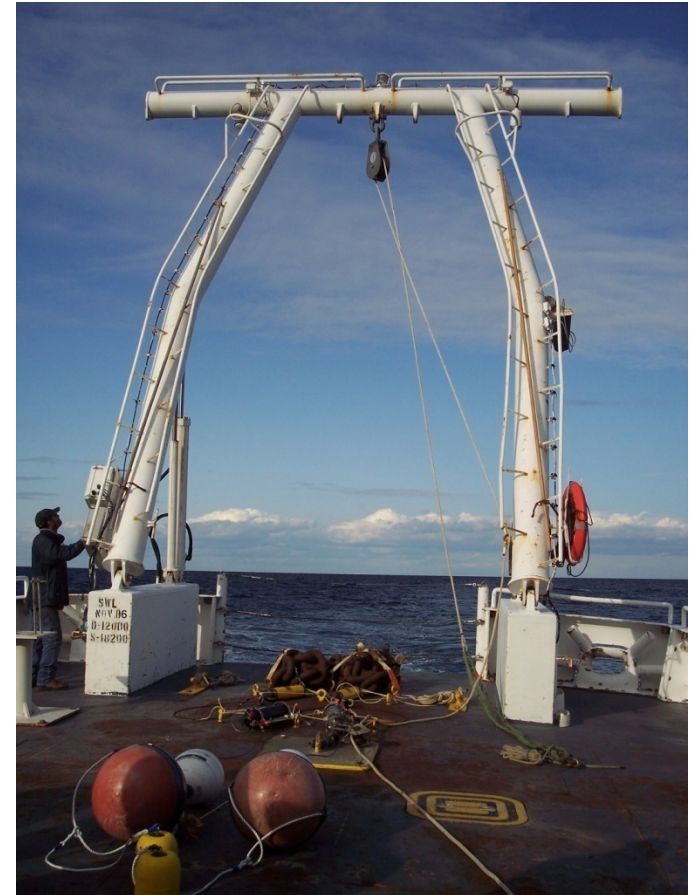
- Perform a detailed analysis of the electromagnetic field conditions in the candidate locations.
- Predict the electric and magnetic (EM) fields due to the wind farm and associated cabling.
- Estimate the effects of the added EM fields on marine mammals, fish, turtles and other animals native to the region.



Underwater cable trencher (Chris)

# Tasks

1. Collect acoustic data using calibrated systems in air and underwater in the region.
2. Collect EM field data using calibrated systems in air.
3. Build a noise prediction model for the wind farm so average intensity of the radiated noise for various candidate designs, operating conditions and locations can be estimated.



# Tasks (cont.)

4. Quantify the effects of the added noise, including predicting the number of takes of marine mammals, fish, turtles, and other protected species that may occur in the region.
5. Quantify the effects of the added electromagnetic fields (EMF) on marine mammals, fish, turtles, and other protected species that may occur in the region



Loggerhead turtle (NGS)

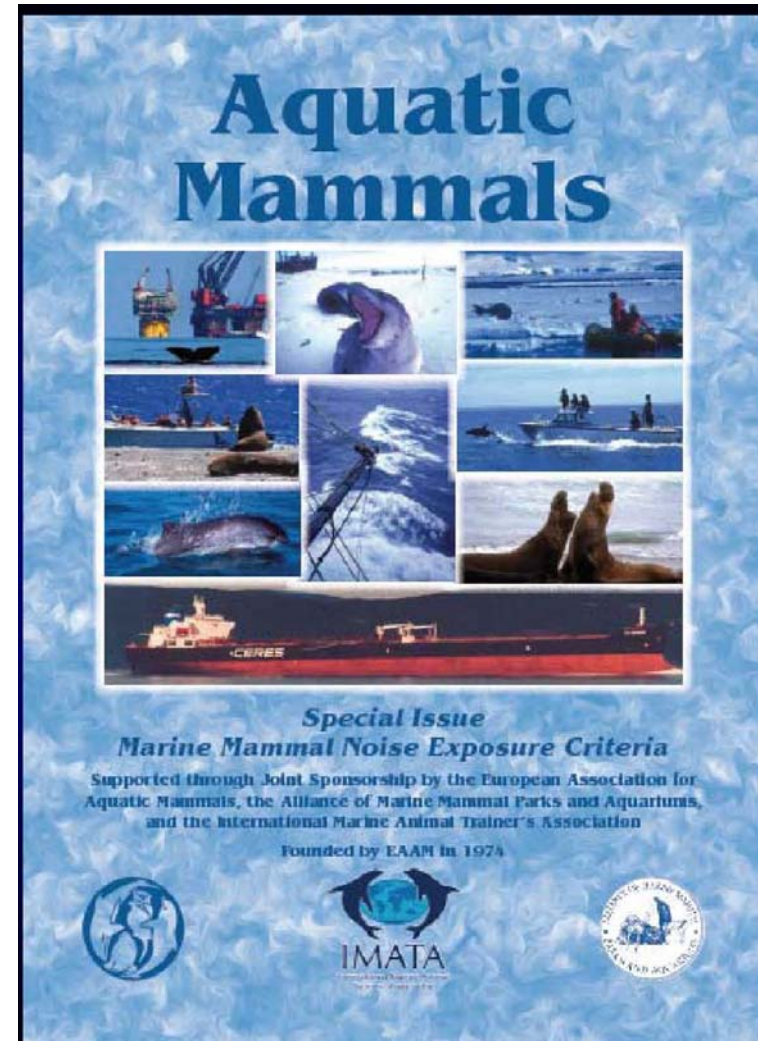
# Marine Mammal Protection Act: Definitions

- “Take” includes harassing, hunting, capturing, or killing, or attempting to do any of those things.
- Harassment is defined as any act of pursuit, torment, or annoyance which
  - Has the potential to injure a marine mammal or stock in the wild (Level A) or
  - Has the potential to disturb a marine mammal or stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering (Level B).



# Acoustic Criteria for Injury and Behavioral Effects on Marine Mammals

- We have recently published a paper in Aquatic Mammals on Marine Mammal Noise Exposure Criteria
- We have surveyed all of the published literature on the effects of sound on marine mammals and recommended new criteria for Injury and Behavioral Effects



# New Criteria for Marine Mammals

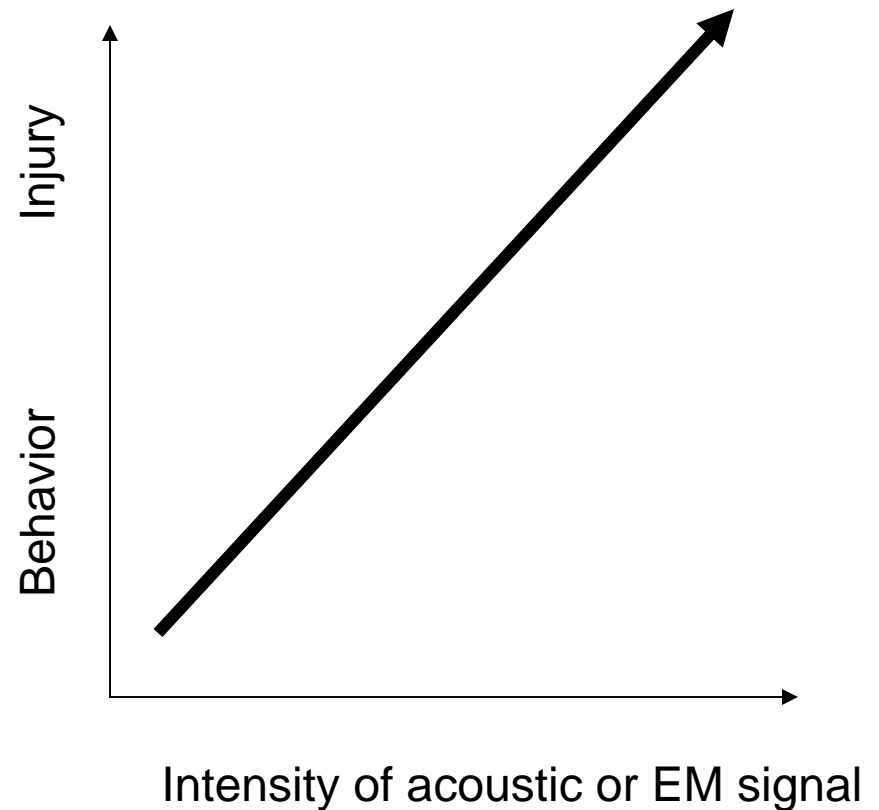
- We have recommended new criteria for auditory injury for groups of marine mammals
  - Low frequency whales (Blues, right whales, etc.)
  - Mid frequency cetaceans (Sperms, bottle nose dolphins, etc.)
  - High frequency cetaceans (Porpoise, river dolphin, etc.)
  - Pinnipeds in air and water (Harbor seals, sea lions, etc.)





# Effects on Animals

- When we study the effects of a man-made system on marine animals, we break down the effects into two main categories
  - injury
  - behavioral modification



# Human Connection

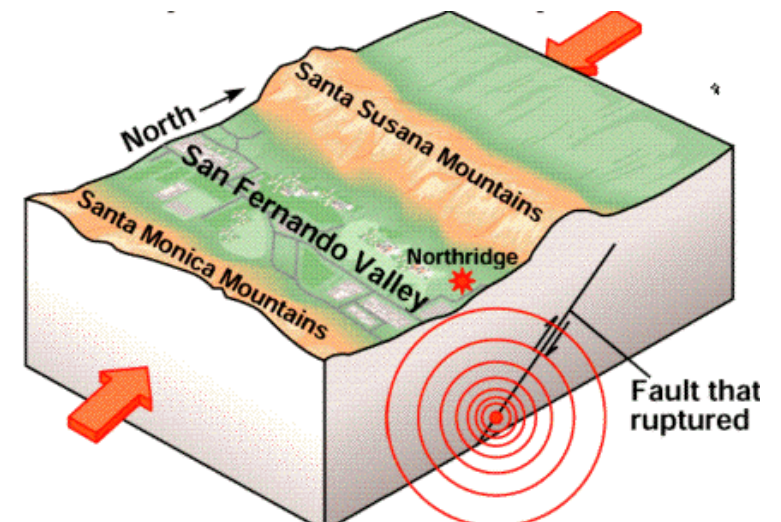
- Let's use intensity and duration of sun exposure on the beach



- The more intense the sun and the longer we sit on the beach, the more likely we change our behavior and perhaps even get injured.

# Acoustic Spectrum

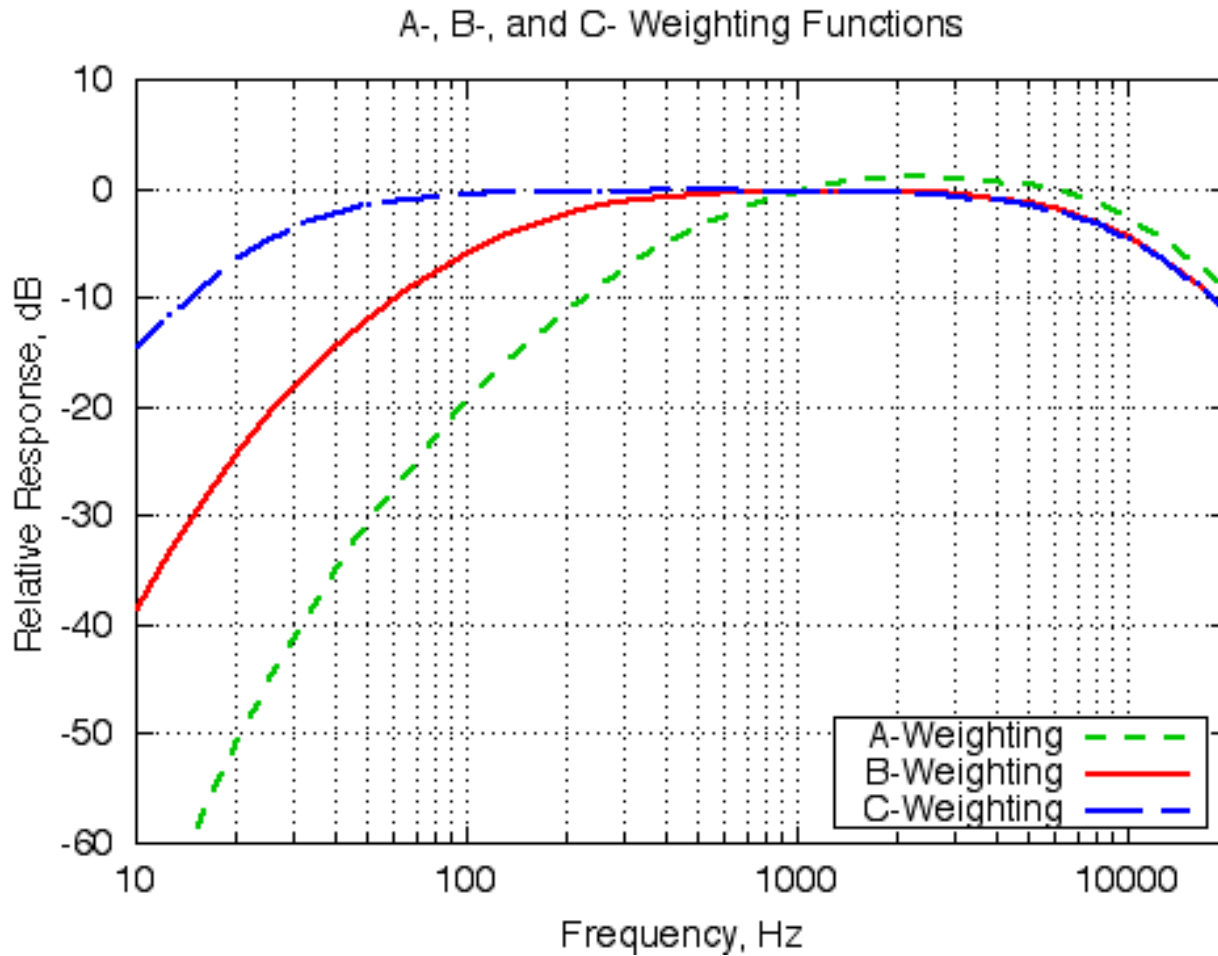
Frequency (Hz)	Name	Uses
$10^6$	1 megahertz	Medical ultrasound
$10^5$	100 kilohertz	Dolphin and bat echolocation
$10^4$	10 kilohertz	Near the top of human hearing, dolphin communication
$10^3$	1 kilohertz	Near the best human hearing
$10^2$	100 hertz	Near bottom of dolphin hearing
10	10 hertz	Near bottom of human hearing, large whale communication
1	1 hertz	Earthquakes



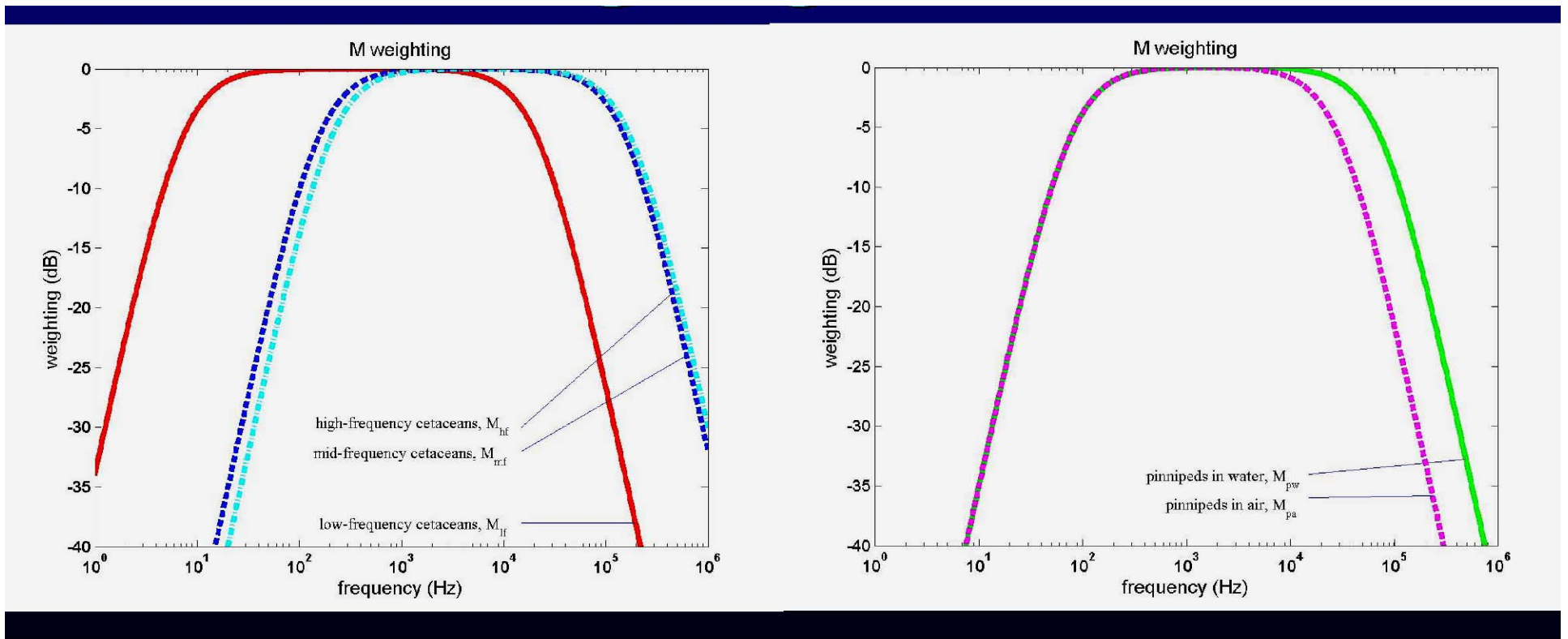
**Table 2.** Functional marine mammal hearing groups, auditory bandwidth (estimated lower to upper frequency hearing cut-off), genera represented in each group, and group-specific (M) frequency-weightings

Functional hearing group	Estimated auditory bandwidth	Genera represented (Number species/subspecies)	Frequency-weighting network
Low-frequency cetaceans	7 Hz to 22 kHz	<i>Balaena, Caperea, Eschrichtius, Megaptera, Balaenoptera</i> (13 species/subspecies)	$M_{lf}$ (lf: low-frequency cetacean)
Mid-frequency cetaceans	150 Hz to 160 kHz	<i>Steno, Sousa, Sotalia, Tursiops, Stenella, Delphinus, Lagenodelphis, Lagenorhynchus, Lissodelphis, Grampus, Peponocephala, Feresa, Pseudorca, Orcinus, Globicephala, Orcaella, Physeter, Delphinapterus, Monodon, Ziphius, Berardius, Tasmacetus, Hyperoodon, Mesoplodon</i> (57 species/subspecies)	$M_{mf}$ (mf: mid-frequency cetaceans)
High-frequency cetaceans	200 Hz to 180 kHz	<i>Phocoena, Neophocaena, Phocoenoides, Platanista, Inia, Kogia, Lipotes, Pontoporia, Cephalorhynchus</i> (20 species/subspecies)	$M_{hf}$ (hf: high-frequency cetaceans)
Pinnipeds in water	75 Hz to 75 kHz	<i>Arctocephalus, Callorhinus, Zalophus, Eumetopias, Neophoca, Phocarcos, Otaria, Erignathus, Phoca, Pusa, Halichoerus, Histriophoca, Pagophilus, Cystophora, Monachus, Mirounga, Leptonychotes, Ommatophoca, Lobodon, Hydrurga, and Odobenus</i> (41 species/subspecies)	$M_{pw}$ (pw: pinnipeds in water)
Pinnipeds in air	75 Hz to 30 kHz	Same species as pinnipeds in water (41 species/subspecies)	$M_{pa}$ (pa: pinnipeds in air)

# Human Hearing Weights



# M-Weighting



We have introduced M-weighting for four different groups of animals: low frequency cetaceans, mid-frequency cetaceans, high-frequency cetaceans and pinnipeds (air and water).

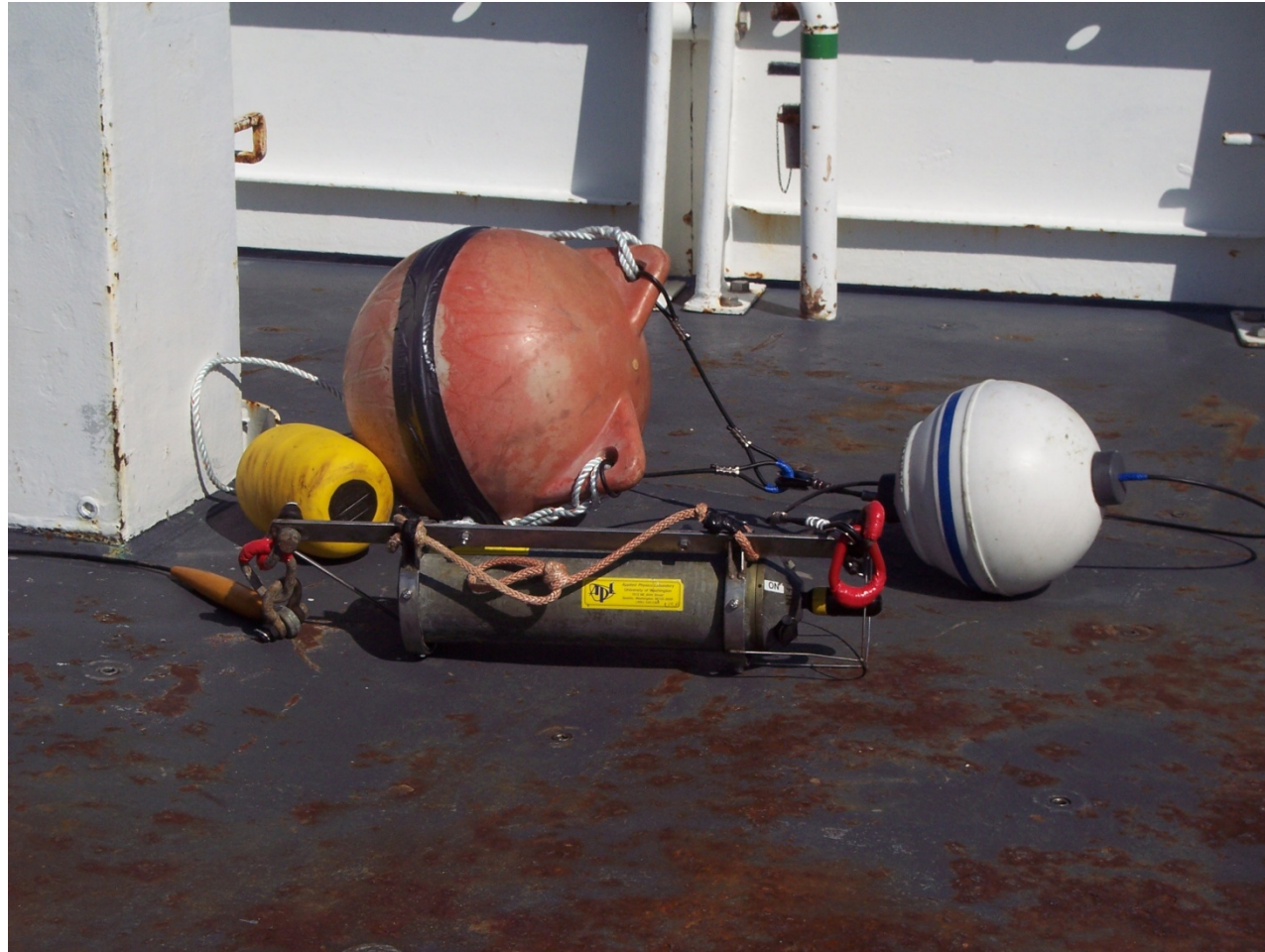
# Progress To Date

- Two Passive Acoustic Listener (PAL) systems deployed south and southwest of Block Island from October 6 to November 14, 2008.
- Systems recorded underwater acoustic ambient noise spectra and signal snippets (4 sec long) every 3 minutes
- Ship position data collected for the time period from the Automatic Identification System for correlation with acoustic data analysis
- Data collection was successful and analysis is in progress



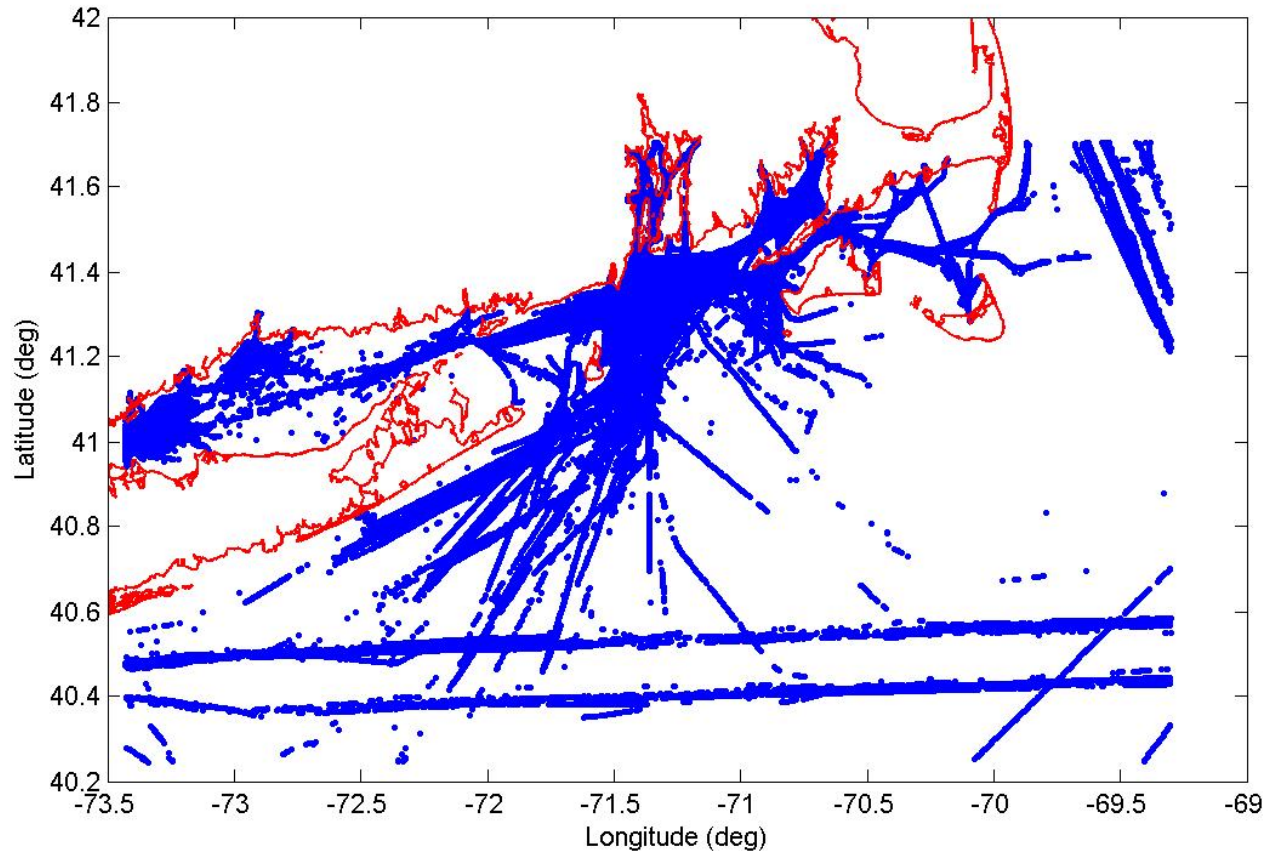
R/V Endeavor (GSO)

# Passive Acoustic Listener System and Mooring Equipment



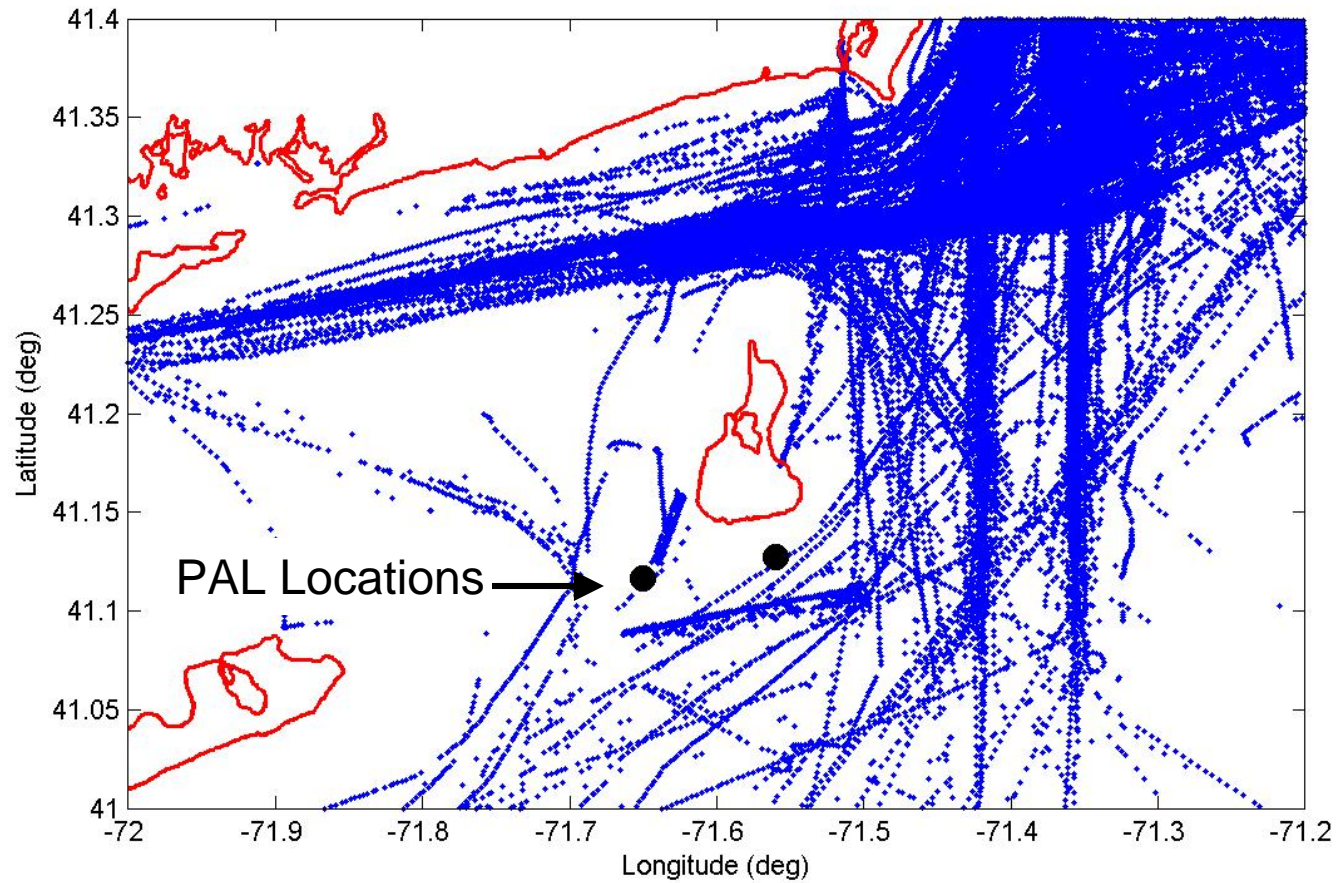


# Shipping Positions from Automated Identification System (AIS)

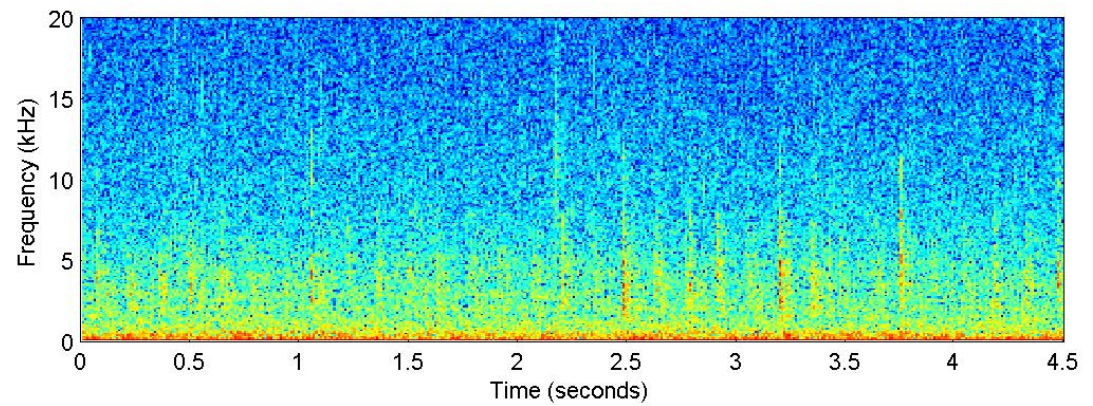
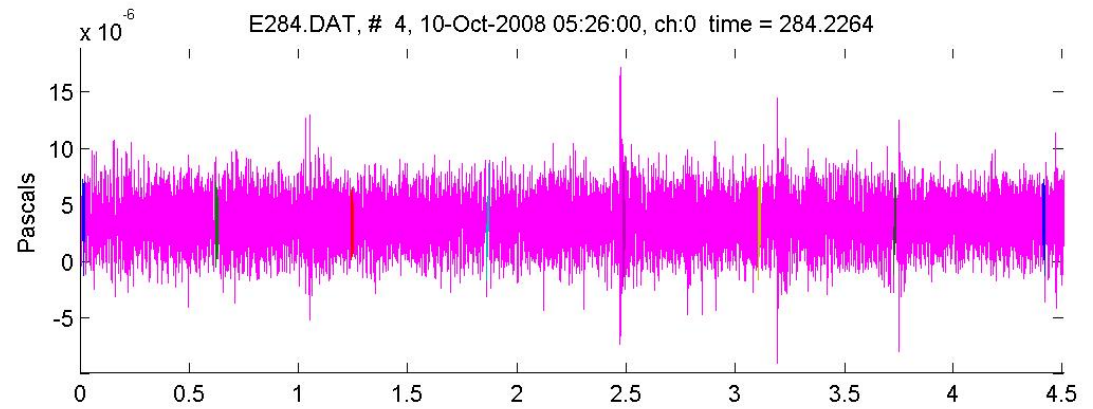


Data from the AIS for the period from October 6 to November 14 is shown and will be used to analyze the acoustic noise data.

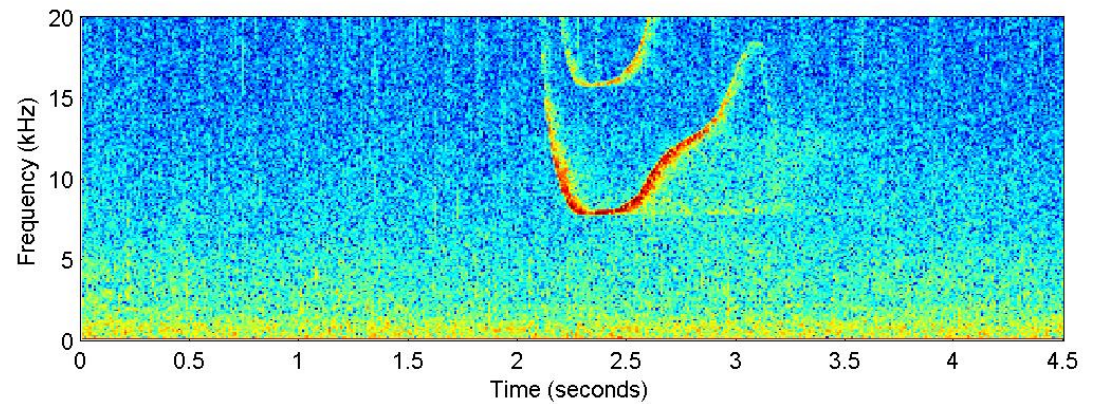
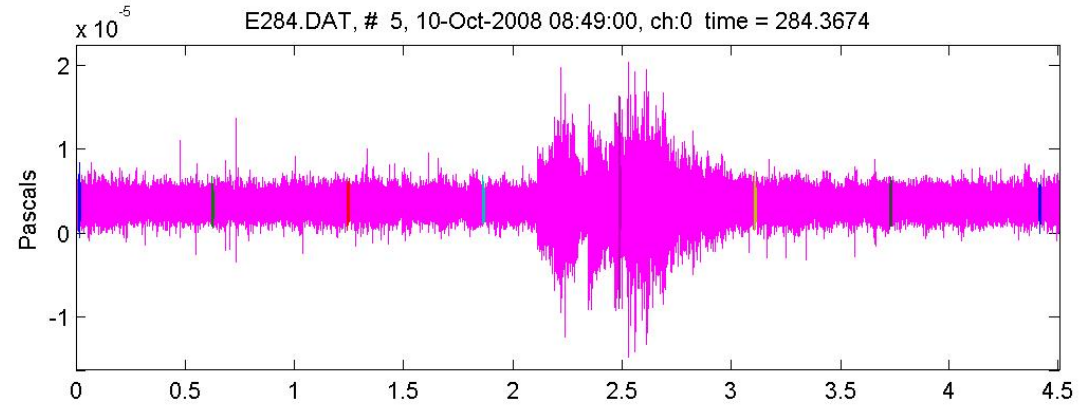
# AIS-Derived Ship Positions Near Block Island



# Acoustic Signal from Passing Ship

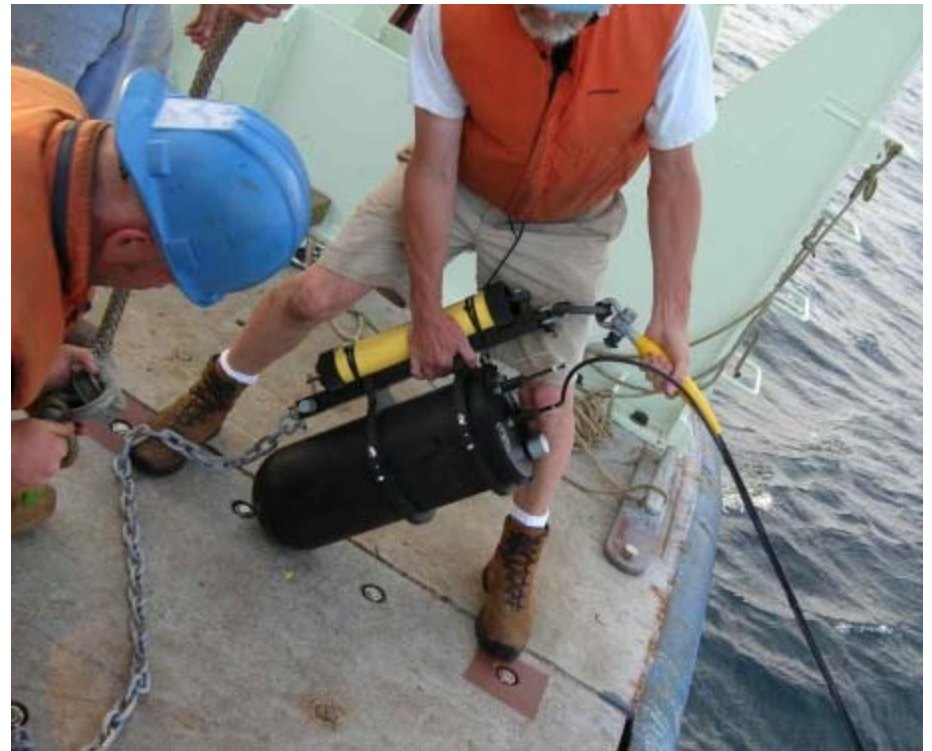


# Acoustic Signal from Dolphin

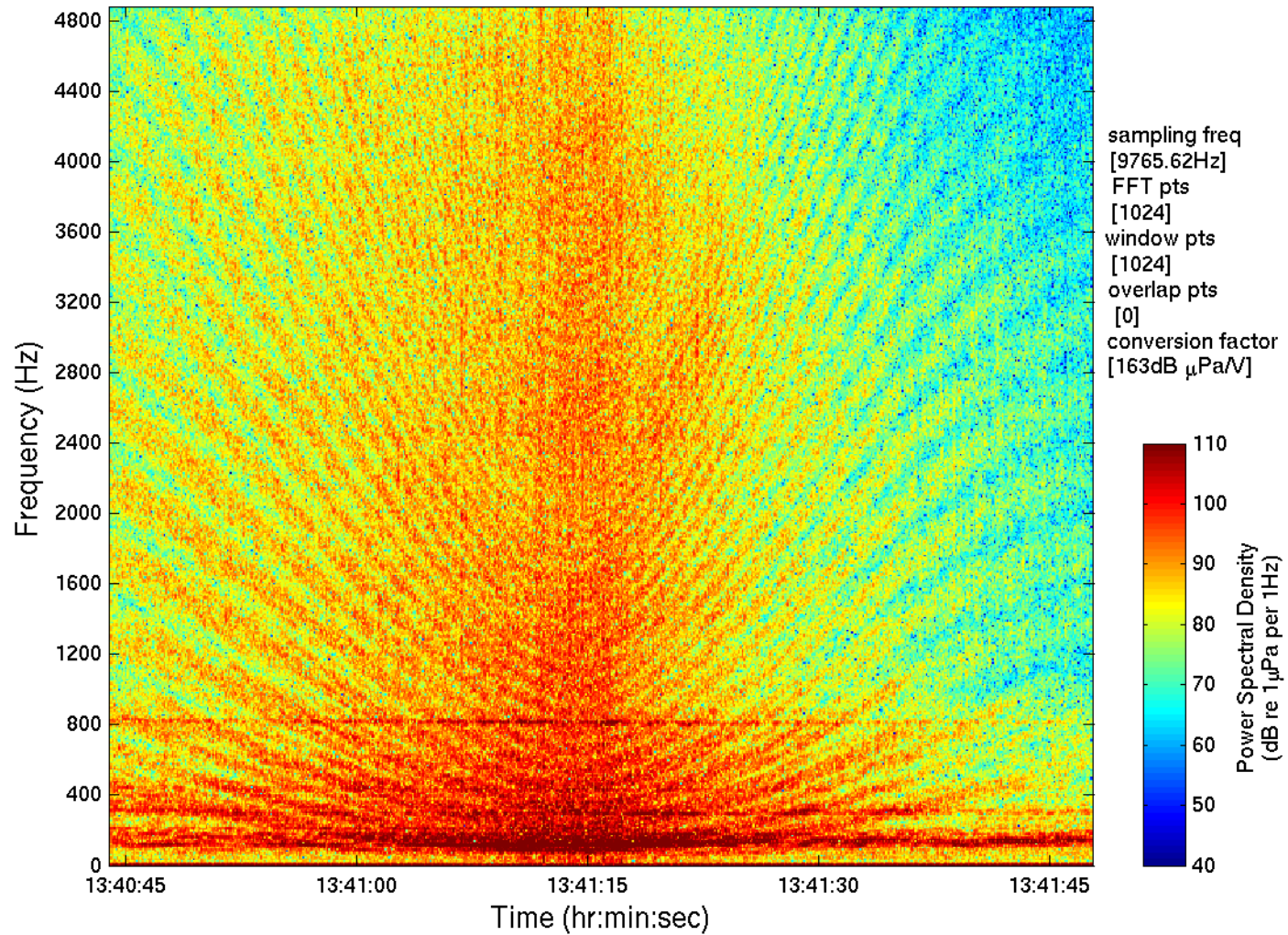


# Ocean Acoustic Work This Summer

- We are planning to deploy another type of acoustic recorder: Single Hydrophone Receive Units (SHRU)
- Two units will be deployed for one month
- SHRU's record continuously for 1 mo.



SHRU3\_sw53, 08131210.DAT, Starting Time: 13-Aug-2006 13:40:44



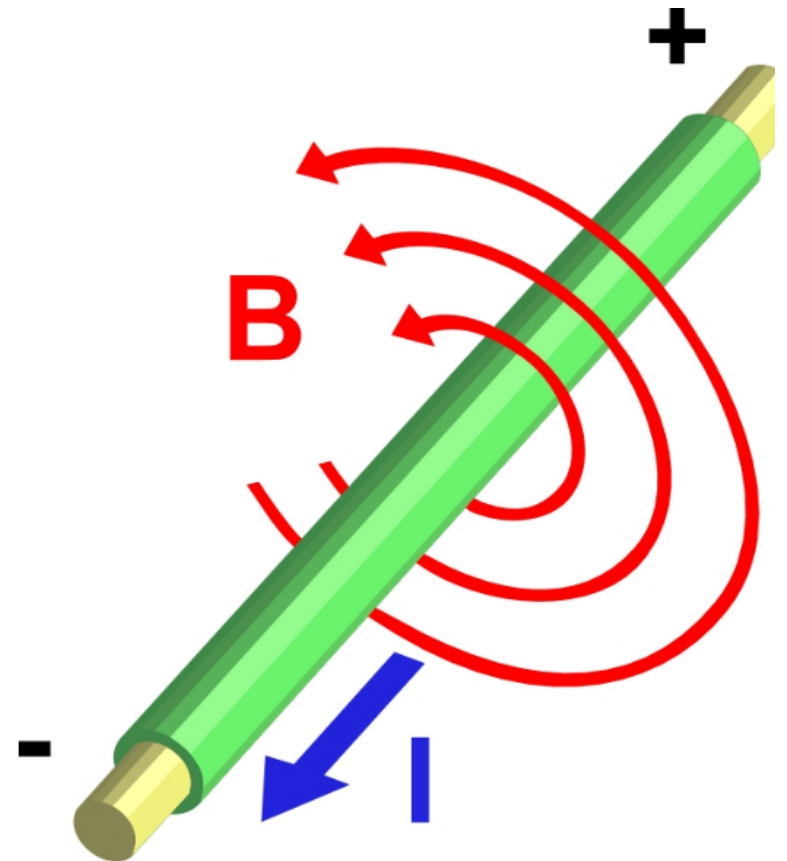
# Air Acoustic Work This Summer

- We are scheduled to measure atmospheric ambient noise this summer on Block Island Mohegan Bluffs and offshore



# Electric and Magnetic Field Effects

- The EM effects portion of our project just getting started.
- Measurements of the ambient EM field on Block Island and in the region offshore to be completed this summer.
- The Cape Wind EIS has information pertinent to this study and we will briefly review their conclusions on this topic.



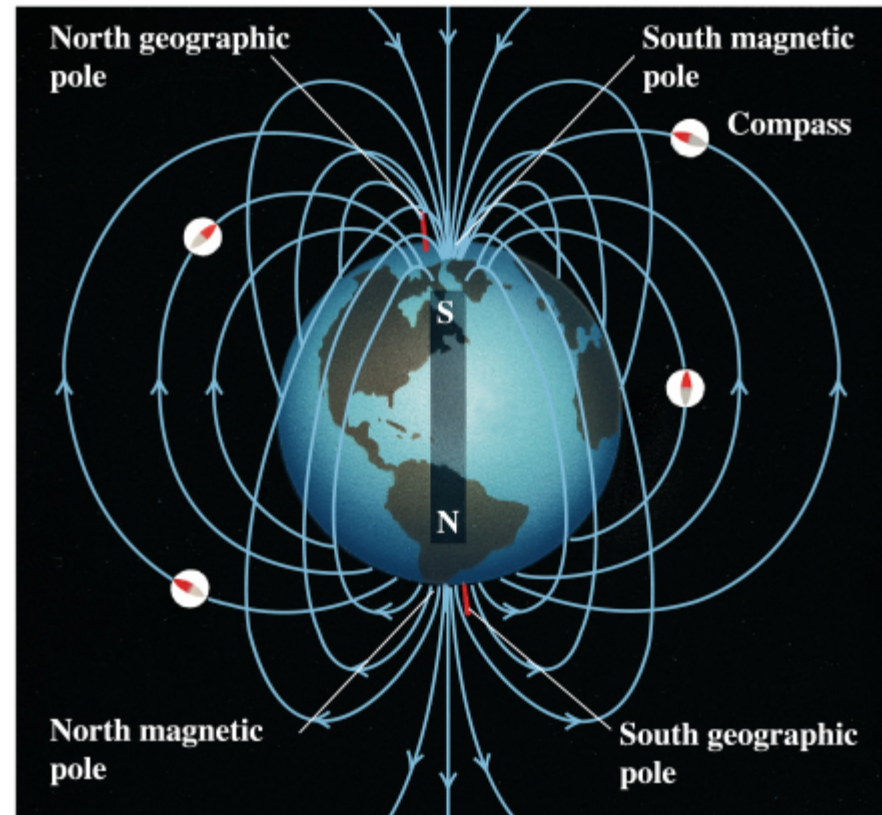


# Electrical and Magnetic Fields (EMF)

- Electric power transmission and distribution lines create Electrical and Magnetic Fields (EMF) because they carry electric currents at high voltage.
- Electric field is measured in units of volts/m (V/m) or kilovolts/m (kV/m). Magnitude of the magnetic field or magnetic flux density is measured in gauss (G). Smaller fields are measured in milligauss (mG).
- Strength of powerline EMFs diminish with distance from the source. Electric fields are attenuated by objects (such as trees and walls) and are completely shielded by electrically conducting materials. Magnetic fields, on the other hand, penetrate most materials.

# Magnetic Fields on Earth

- The Earth generates a magnetic field caused by liquid iron in the outer core.
- Dynamo theory describes the process through which a rotating, convecting, and electrically conducting fluid acts to maintain a magnetic field.
- Field strength varies from 0.3 G in South America and South Africa to 0.6 G near the magnetic poles.
- This is a DC or non-alternating field

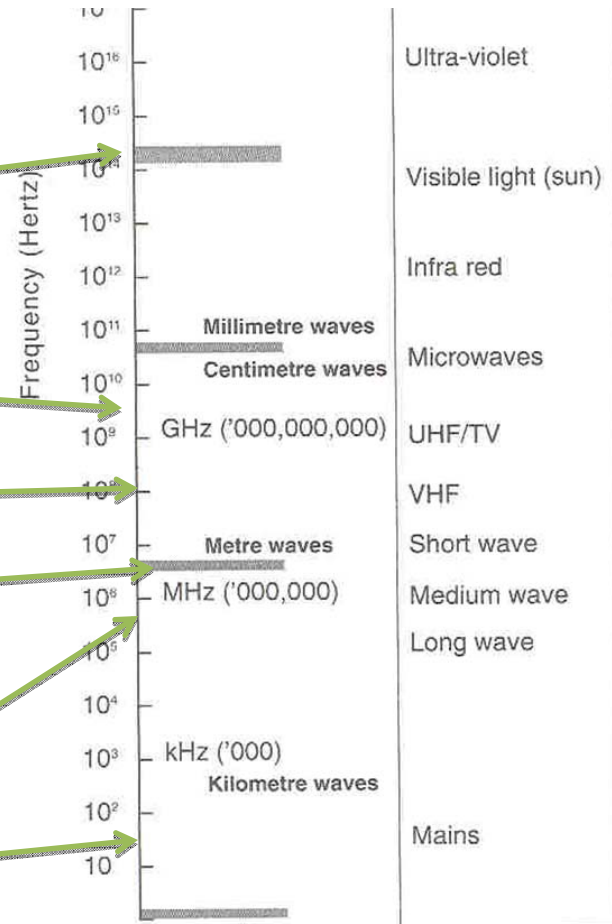


Copyright © Addison Wesley Longman, Inc.

# EM Spectrum

- The Electromagnetic Spectrum includes

- Light at about 1 THz
- Microwave oven frequency of 2.45 GHz
- VHF and UHF TV transmissions at 54 and 806 MHz
- Short wave radio at 2.3 MHz–26.1 MHz
- Medium wave AM radio at 520 kHz to 1,610 kHz
- very low frequency emissions from power lines at 60 Hz,



# Electric and Magnetic Field Measurements (Cape Wind Project)

- Baseline measurements of power frequency magnetic flux density were made along the proposed onshore transmission cable route.
- Based on this measurements and the physical characteristics of the planned cable system, projections of the magnetic flux density were made that would be representative of the worst case conditions during peak electrical load.
- Maximum magnetic flux density measured were of the order of 2 to 40 mG. (peak load experienced was 27 MW). Existing electric field strength varied between 0.01 kV/m to 0.09 kV/m.
- Results from studies have shown that electric fields in the home, on average, range from 0 to 10 Volts/m and magnetic fields range from 0.6 to 3 mG. This is an AC or alternating field at the 60 Hz.

# Health Effects Associated with EMF

- The scientific evidence suggesting that EMF exposure poses any health risk is weak
- Extensive investigations of animals exposed to higher levels of EMF (50,000 mG) have not demonstrated any adverse health effects.
- Weak electric fields can be detected by certain fish (rays and sharks) for use in orientation and prey location.
- Data from the Nysted Offshore Wind Farm (Denmark) have documented some effects from offshore cable routes on fish behavior indicating avoidance or attraction depending on the species. However the observed phenomena were not significantly correlated with the strength of the EMF.
- The cable systems are shielded, which effectively block the electric field produced by the conductors.

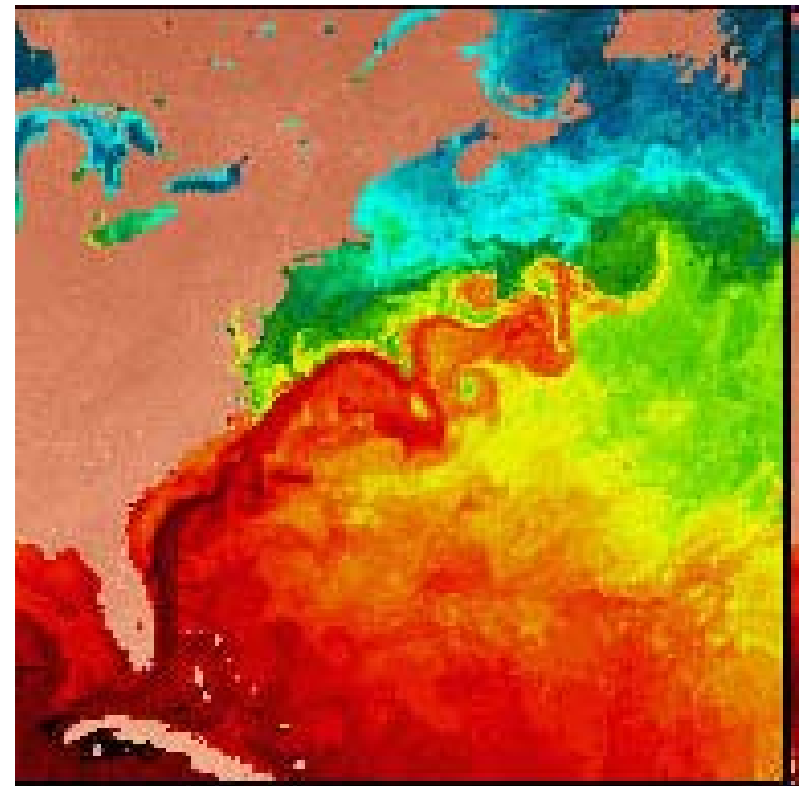


# Summary of Cape Wind EM Study

- Primary consideration is for organisms that may have magnetic sense organs.
- The minimum 60 Hz magnetic flux density would have to exceed 50 mG for any effect.
- This level is expected to occur only in the immediate vicinity of the power line.
- Marine benthos such as bi-valves and worms may spend more time in the vicinity of the buried offshore cables and hence may experience more exposure.
- Measurements will be made to ensure that high levels of EMF are not present.

# Long Term Science Potential

- The measurements made by this program has additional science benefits including:
  - changes in the pH due to CO<sub>2</sub> absorption could change the attenuation of sound in the ocean affecting the noise levels
  - an ocean acoustic tomography system using the RI Wind Farm Met Tower passive acoustic measurements could be valuable in estimating the temperature and strength of the cold water flowing south along the continental shelf



# www.dosits.org

The screenshot shows a Mozilla Firefox browser window displaying the website 'Discovery of Sound in the Sea'. The browser's address bar shows the URL 'http://dosits.org/'. The website's main header features the title 'Discovery of Sound in the Sea' in a large, blue, serif font. Below the title is a navigation menu with links for 'Science', 'People', 'Animals', 'Resources', 'Media', 'Teacher', 'Student', 'Galleries', 'Audio', 'Scientist', and 'Technology'. A secondary navigation bar includes links for 'About DOSITS', 'Site Map', 'Glossary', and 'Search'. The main content area is a grid of nine categories, each with a representative image and a caption: 'Media Resources' (book cover), 'Science of Sound' (sound wave diagram), 'Scientist Gallery' (person with dolphin), 'Teacher Resources' (person with chart), 'Animals and Sound' (dolphins), 'Audio Gallery' (person on phone), 'Student Resources' (group of people), 'People and Sound' (ship deck), and 'Technology Gallery' (yellow crane). At the bottom, a text box provides an overview of the site's purpose.

Discovery of Sound in the Sea - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://dosits.org/

Most Visited Google Metro Bay SAMP RI Coastal Resources ... Sign Off Citizens Bank | Citizen... Index of ftp://ftp.one... WebCalendar Bank of America | Ho... WebCalendar

## Discovery of Sound in the Sea

Science • People • Animals • Resources • Media • Teacher • Student • Galleries • Audio • Scientist • Technology

About DOSITS • Site Map • Glossary • Search

**Media Resources**

**Science of Sound**

**Scientist Gallery**

**Teacher Resources**

**Animals and Sound**

**Audio Gallery**

**Student Resources**

**People and Sound**

**Technology Gallery**

Oceanographers, submariners, whales, dolphins, seals, in short, all working or living in the ocean use sound to sense their surroundings, to communicate, and to navigate. This web site will introduce you to the science and uses of Sound in the Sea.