

Chapter 148

Discovery of Sound in the Sea: Resources for Educators, Students, the Public, and Policymakers

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Abstract There is increasing concern about the effects of underwater sound on marine life. However, the science of sound is challenging. The Discovery of Sound in the Sea (DOSITS) Web site (<http://www.dosits.org>) was designed to provide comprehensive scientific information on underwater sound for the public and educational and media professionals. It covers the physical science of underwater sound and its use by people and marine animals for a range of tasks. Celebrating 10 years of online resources, DOSITS continues to develop new material and improvements, providing the best resource for the most up-to-date information on underwater sound and its potential effects.

Keywords Communication • Acoustics • Marine animals • Sound effects • Underwater sound

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1 Background to the Development of the Discovery of Sound in the Sea

The scientific community and the general public have become increasingly aware of and concerned about underwater sound (Nowacek et al. 2007; Southall et al. 2007; Popper and Hastings 2009; Ellison et al. 2012; Moore et al. 2012; Popper and Hawkins 2012). There is both an interest in learning about the sources and uses of underwater sound and a need for up-to-date peer-reviewed resources on the potential effects of sound on the ocean and its inhabitants. However, understanding the acoustics and related physics as well as the complexities of these phenomena in air versus water can be challenging. Underwater sound is a complex topic, and there is a shortage of resources available at an introductory level.

The primary goals of the Discovery of Sound in the Sea (DOSITS) are to provide a comprehensive resource, based on peer-reviewed science, for multiple user groups; to provide training opportunities for educators, policy makers, and the media; to reach the widest audience possible; and to inspire the next generation of scientific explorers. Another goal for the site is for it to serve as a resource that dispels popular myths, often found in the popular media or advocacy-based Web sites and materials. Content, such as the effects of sonar on marine life, is based on peer-reviewed publications and has undergone rigorous review by the DOSITS scientific advisory panel.

The DOSITS Web site has been designed to provide accurate scientific information on underwater sound at levels appropriate for all audiences, including the general public, K-12 teachers and students, college students, policy makers, and professionals in industry, education, and the media (Vigness-Raposa et al. 2008, 2012). The DOSITS Web site covers the physical science of underwater sound and how sound is used by people and marine animals for a wide range of tasks and behaviors from exploration to communication and survival in three main science sections. There are also three resource sections, with information designed for teachers, students, and the media. The site's three galleries focus on underwater sounds (Audio Gallery), scientific equipment (Technology Gallery), and acoustics-related research (Scientist Gallery).

The DOSITS Web site was launched in November 2002, but it has not been static either in content or in structure. The content undergoes major reviews twice annually and continues to grow with monthly updates and improvements as new scientific literature is published. Working with a professional Web design team, the DOSITS Web site was relaunched in March 2010 with a fresh "look and feel" that maintains functionality and content (Vigness-Raposa et al. 2012). The redesign included an interactive front page, an interactive Audio Gallery, and a redesigned Scientist Gallery.

The significance of the DOSITS resource is evident in the fact that the Web site has received approximately 63 million "hits" over its first 10 years, with Web traffic spiking during the 2010 relaunch and continuing to increase over the years (Fig. 148.1). In 2012, the DOSITS Web site saw a 20% increase in traffic over 2011, receiving over 10 million hits/year. This illustrates the level of public and professional education and scientific interest in this increasingly important topic and its value to the underwater acoustics community.

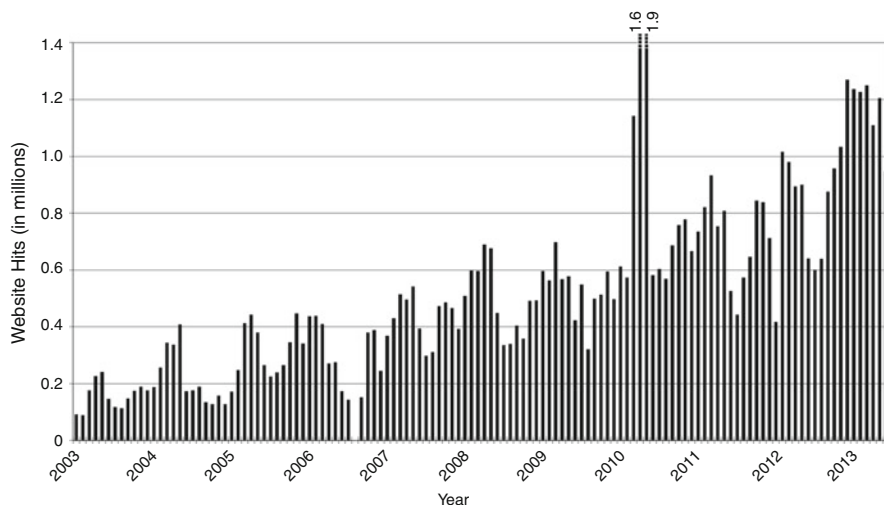


Fig. 148.1 The number of Web site “hits” (in millions) per month from January 2003 through June 2013

2 Overview of the DOSITS Web Site

The DOSITS Web site includes three major science sections: the Science of Sound in the Sea, People and Sound in the Sea, and Animals and Sound in the Sea. These three major sections include ~400 pages of content, which provide a thorough introduction to underwater acoustics, its many uses, and the appropriate level of concern regarding the potential effects on the environment with both basic level information and in-depth discussions of important science topics.

All DOSITS information is based solely on published peer-reviewed scientific research. Related research literature is continuously monitored for new information that is regularly added to the Web site content and resources, ensuring that the most up-to-date results are incorporated into the DOSITS resource. In addition, the Web site regularly undergoes a thorough review by a panel of four to eight scientific experts in each of the major topic fields to ensure the highest scientific accuracy and integrity.

The Science of Sound in the Sea section (<http://www.dosits.org/science/science-summary/>) provides a thorough introduction to the physical science of underwater sound. The Science of Sound in the Sea section includes such topics as sound movement, sound measurement, and the difference between sound in air and sound in water.

People and Sound in the Sea (<http://www.dosits.org/people/peoplesummary/>) includes information on the many important everyday activities that humans do in and on the ocean that depend on sound for success. Navigation, fishing, communication, and research and exploration are just a few examples of the tasks that require the use of underwater sound.

Animals and Sound in the Sea (<http://www.dosits.org/animals/animalsandsound-summary/>) includes information on how marine animals produce and receive sound

and use sound to sense their surroundings, communicate, locate food, and protect themselves underwater. The Animals and Sound in the Sea section also includes an in-depth discussion on the current state of knowledge of the effects of underwater sound on marine mammals, fishes, and invertebrates.

As the DOSITS Web site has progressed, advanced level content that is appropriate for high-school physics classes and undergraduate and early graduate-level science classes has been added to each science section. These Advanced Topics are described in Section 4.

The DOSITS Web site also has three Galleries. The Audio Gallery (<http://www.dosits.org/audio/>) contains more than 100 underwater sounds from marine mammals, marine invertebrates, fishes, human activities, and natural phenomena. The Audio Gallery includes a flash-based interactive that displays pictures, videos, and audio files with spectrograms and waveform displays (see Section 3) as well as nonflash pages with background descriptions of the sound source and audio files in QuickTime and MP3 formats.

The Scientist Gallery (<http://www.dosits.org/scientist/>) highlights the cutting edge research of five renowned scientists in the field of underwater acoustics. Video clips of interviews with the scientists, along with accompanying transcripts, allow the users to learn what motivated the scientists to become acousticians and the educational and learning processes they underwent to become world-class researchers. The Scientist Gallery also includes pages describing their research as well as their biographies.

The Technology Gallery (<http://www.dosits.org/technology/techsummary/>) contains images and descriptions of the scientific and commercial equipment that is used by humans for everyday tasks. Because light is relatively opaque underwater and sound is transparent, sound must be used for a wide variety of tasks, from observing the seafloor and locating objects underwater to advanced research tasks such as measuring ocean currents and temperature.

In addition to the Galleries, there are three Resources sections. The Media Resources section (<http://www.dosits.org/resources/media/>) contains a frequently asked questions (FAQ) briefing designed to provide scientific answers to the most commonly asked questions about underwater sound and its effects on marine life. The Media Resources section also includes a facts and myths quiz that tests the reader's understanding of the complex topic of underwater sound, providing answers and links to pages on the DOSITS Web site for further information. In addition to these Internet resources, there is a 16-page booklet and a trifold brochure that are available in print and as downloadable PDF files on the Web site. These resources have recently been translated to languages other than English (see Section 5).

The Teacher Resources section (<http://www.dosits.org/resources/teachers/>) includes a list of helpful classroom resources along with classroom activities developed by K-12 educators and educational professionals. A recent update includes a complete and practical classroom instruction guide on *How To Build a Hydrophone* activity (<http://www.dosits.org/resources/all/classroom/buildhydrophone/>). The activity now includes detailed directions accompanied by photographs that outline the equipment to

be used and demonstrates crucial steps as the hydrophone takes shape. In addition to classroom activities, PowerPoint presentations designed for classroom use of the Web site content are available for downloading. The Teacher Resources section also includes structured tutorials on the topics of the science of underwater sound, the technologies used with underwater sound, and the potential effects of underwater sound, both natural and anthropogenic, on marine life. These structured tutorials are designed as linear learning resources with progressively developed stages of knowledge, thereby guiding educators in the sequence of learning development for these three critical topics. The Student Resources section (<http://www.dosits.org/resources/students/>) also includes the structured tutorials.

3 Improvements to the Audio Gallery

The front page of the Audio Gallery includes a flash-based interactive that allows the user to efficiently select and move between sound sources (Fig. 148.2). This is done by selecting either the “Category” or “Taxonomy” radio button and using the provided drop-down menu. The Category drop-down menu includes Marine Mammals–Baleen Whales, Marine Mammals–Toothed Whales, Marine Mammals–Pinnipeds,



Fig. 148.2 A screen capture of the flash-based interactive of the Audio Gallery Web page (www.dosits.org/audio/) developed for the Discovery of Sound in the Sea (DOSITS) Web site relaunch in March 2010

Marine Mammals–Sirenians, Marine Invertebrates, Fishes, Other Natural Sounds, and Anthropogenic Sounds. Taxonomy refers to the Linnean system in biology commonly used for classifying animals based on anatomical similarities and ancestry. On DOSITS, the family levels are used, which is particularly useful for categorization and comparison of the vocalizations of fishes. Other natural and anthropogenic sounds are listed below the families.

The Audio Gallery interactive window was recently expanded to include a sound visualization tool that is launched when an audio file is selected for a particular sound source. When a sound of interest is selected in the interactive window, the sound is heard and the sound visualization tool displays a spectrogram and waveform within the interactive window. As the sound plays, a scroll bar reveals the spectrogram and waveform so that the viewer can simultaneously hear the sound and visually see the changes in the frequency and pressure components of the sound.

4 Expansion of Advanced Topics

Within the three major science sections, Advanced Topics are included that address the content that would be appropriate for high-school, undergraduate, and early graduate levels. Although the majority of the DOSITS Web pages do not include mathematical formulae and are written for a typical newspaper reader (8th-grade reading levels), Advanced Topics include mathematical formulae and advanced scientific principles that extend the reader's understanding of related science concepts in physics, acoustics, biology, and even chemistry as appropriate. Sample topics include Introduction to Decibels, Scientific Method, Scientific Uncertainty, and Temporary Threshold Shift (TTS) Studies. As these titles suggest, Advanced Topics such as Scientific Method and Scientific Uncertainty are appropriate for many audiences, but some can also be quite specialized, such as TTS Studies.

Advanced Topics have recently been expanded to include new pages on hearing and impulsive and explosive sound sources. The new advanced sections on impulsive and explosive sound sources describe the acoustics of underwater explosions, which are significantly different from that of a coherent source like a fish finder or acoustic projector. How these differences in acoustics can change the effects experienced in the marine environment are also discussed.

The two new Advanced Topics pages on hearing focus on (1) how some vertebrate animals hear different components of sound and (2) advanced scientific descriptions of those sound components, including how sound can be characterized by particle motion, pressure, and intensity. Respectively titled What Components of Sound Are Used for Hearing? (<http://www.dosits.org/animals/advancedtopics/componentsofsound/>) and What Is Intensity? (<http://www.dosits.org/science/advancedtopics/whatsintensity/>), these sections focus on key sound components (pressure and particle motion) and clarify the relationships between intensity, pressure, and particle velocity. In addition, there is a new Advanced Topic that describes the evolution of hearing in odontocetes, with an animation that steps through the evolutionary phases.

5 Media Resources in Multiple Languages

It is recognized that the media have unique professional needs, with imminent publishing deadlines that benefit from efficient access to accurate scientific information. The DOSITS team appreciates that print resources at hand may be more useful for certain audiences than Internet Web pages. Therefore, in addition to the extensive content found on the DOSITS Web site, there is a 16-page educational booklet (<http://www.dosits.org/resources/all/downloads/publications/booklet/>) and a trifold brochure (<http://www.dosits.org/resources/all/downloads/publications/brochure/>) that are available in print and as downloadable PDF files on the Web site. The educational booklet is designed for readers that need more comprehensive information in print format. It mirrors the content sections on the Web site but pares down the information to those components deemed essential for understanding the key principles of science topics and associated issues. The trifold brochure is designed to provide a broad-brush overview of the Web site and its 400+ pages of content, with colorful graphics highlighting major features but only the most necessary supporting text. As a road map to locate focal points of information on the DOSITS Web site, the brochure is a means of introducing and encouraging further exploration of the Web site pages.

English is the current language on the Web site, but the DOSITS team recognizes the need to continue to strive to reach as many audiences as possible, particularly in light of our goal to meet the needs of K-12 students. To reach a more diverse audience, print resources have been translated into Spanish and French and reviewed by native speakers. The Spanish booklet has been distributed to educational professionals within Spanish-speaking communities as well as to Mexican commercial vessel operators who conduct whale-watching and fishing tours. The French trifold brochure was distributed at the DOSITS 10th anniversary celebratory symposium held during the International Congress on Acoustics/Acoustical Society of America meeting in Montréal, Canada.

6 Looking Forward After 10 Years of DOSITS

After being online for 10 years, DOSITS continues to achieve its goals of providing comprehensive resource and training opportunities for many user groups. The DOSITS team looks forward to expanding our content on seismic exploration and offshore renewable energy technologies as well as on studies of marine animal distribution and ocean noise budgets in the polar regions as global warming opens these regions to new anthropogenic activities (Moore et al. 2012). The site continues to evolve, reaching the widest audience possible with translations in Spanish and French and encouraging foreign speakers to collaborate with the DOSITS team to further expand resources into other languages. The authors seek to inspire the next generation of scientific explorers with more Advanced Topics, providing them with an overview of the substantial foundation of scientific research that currently exists in the field of underwater acoustics on which they can build.

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