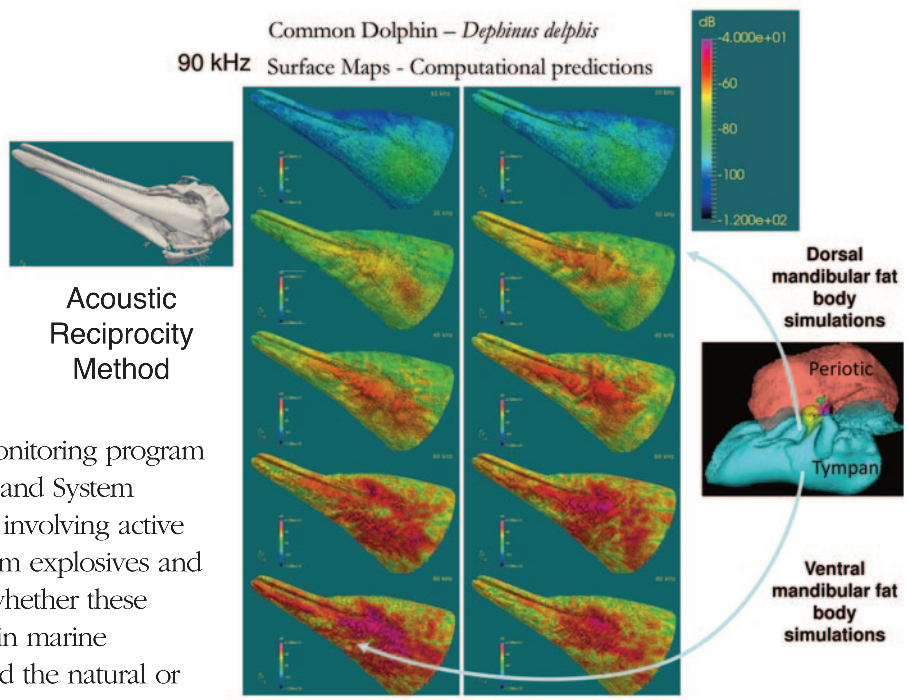
LIVING MARINE RESOURCES PROJECT 15

Jawphone Simulations to Maximize the Utility of Psychoacoustic and Auditory Evoked Potential Experiments



THE NEED

The Navy is responsible for compliance with a suite of Federal environmental laws and regulations that apply to marine mammals and other marine protected species, including the Endangered Species Act and the Marine Mammal Protection Act. As part of the regulatory compliance process associated with these Acts, the Navy is responsible for implementing a marine species monitoring program to assess potential impacts from Fleet and System Command military readiness activities involving active sonar and underwater detonations from explosives and explosive munitions. To understand whether these sound sources are impacting hearing in marine mammals, it is necessary to understand the natural or baseline hearing in these mammals.

Marine mammal hearing thresholds have traditionally been measured using behavioral response paradigms. As this is extremely difficult or impossible for many species, an electrophysiological approach, in which voltages produced by the brain in response to an acoustic stimulus are recorded, is an alternative. These voltages, termed auditory evoked potentials (AEPs), can be quickly measured in subjects with minimal subject cooperation. However, to date basic hearing measures (AEP or behavioral) have only been compiled on a small number of animals, and interpreting AEP results may be more complicated when jawphones are used.

THE SOLUTION

In AEP testing a jawphone–or suction cup containing a transducer–is placed on the head of the marine mammal, and a sound is broadcast. The results of AEP testing can vary depending on the placement, frequency selection, and other parameters of the jawphone. It is the goal of this project to uncover and correct the uncertainty and the errors involved with jawphone placement so that experimental results from AEP may be correctly calibrated.

THE METHODOLOGY

While jawphones have been used for more than two decades in marine mammal research, the mechanisms by which they function are largely unknown. The results of preliminary simulations conducted by Co-Principal Investigators Ted Cranford and Petr Krysl suggest that jawphones selectively excite hearing pathways that may be different from those used naturally by the animals. Cranford and his team found that small changes in the placement of a simulated jawphone can cause large amplitude differences (several decibels) by the time the sounds reach the ears.

Over the past several years Cranford and Krysl have developed a unique methodological test bed that allows them to simulate acoustic disturbances through the complex anatomic geometry of whole heads or bodies, from a broad spectrum of biological specimens (fish to whales). The methodology is based on finite element modeling techniques, where high-resolution computerized tomography (CT) scan data is combined with measurements of tissue properties and custom-built computer programs to simulate sound propagation into and out of the anatomic complexity of specimens. The outputs from these models will quantify the acoustic pathways between the jawphone and the ear, which will enable researchers to compile sensitivity maps that identify the optimal locations for jawphone placement in three dolphin species. These maps can be used to design and evaluate AEP-based hearing tests, guiding jawphone placement in order to minimize errors due to variable response sensitivity to the location of the transducer on the animal's skin.

THE SCHEDULE

Beginning in Spring 2016, the team will build reception-sensitivity maps, first for the bottlenose dolphin, and subsequently for the common dolphin and the killer whale.

NAVY BENEFITS

This modeling environment gives researchers the ability to conduct "virtual experiments" to investigate basic mechanisms of hearing and sound production, and to simulate exposure levels at sound pressures that would be impossible or unethical with live animals. These results will be helpful in the design and evaluation of past and future AEP hearing tests, will significantly reduce lifecycle costs of physical experimentation, and have the potential to reduce environmental impacts.

TRANSITION

The end products will be guidelines and design-of-experiment documents pertaining to the use of AEP in physical experimentation in conjunction with jawphones. These documents will be produced for the bottlenose dolphin, the common dolphin and the killer whale; as well as the minke whale and the fin whale. All researchers currently participating in AEP research will have access to these products.

ABOUT THE PRINCIPAL INVESTIGATORS

Ted Cranford is an Adjunct Professor of Research at San Diego State University Research Foundation. He earned his M.S. in Marine Science and Ph.D. in Biology at the University of California, Santa Cruz. His interests include functional morphology, marine mammal science, bioacoustics, and ecomorphology.

Petr Krysl is a Professor of Computational Mechanics at the University of California, San Diego, Department of Structural Engineering. He holds a Ph.D. in Theoretical and Applied Mechanics from the Czech Technical University in Prague. His current interests include development of finite element methods, especially for applications to biomechanics, mesh generation methods, and high-performance computing.

About the LMR Program

The Living Marine Resources (LMR) program seeks to develop, demonstrate, and assess data and technology solutions to protect living marine resources by minimizing the environmental risks of Navy at-sea training and testing activities while preserving core Navy readiness capabilities. For more information, contact the LMR program manager at exwc_lmr_program@navy.mil or visit www.lmr.navy.mil.

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