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6. Author(s) Ketten, Darlene R.	
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13. Abstract
Computerized tomography (CT and MRI scanning) are powerful tools for imaging inner ear anatomy and pathology in vivo. In humans these imaging techniques are often combined with behavioral and direct physiologic measures of hearing in order to determine hearing status and cause of any loss. Behavioral measures, which consist of simple yes-no replies to a sound stimulus, are possible in trained marine mammals but are not applicable to the large number and diverse species of wild animals that strand and are rehabilitated annually. Physiologic measures, particularly auditory brainstem responses (ABR) and otoacoustic emissions (OAEs), are feasible also for marine mammals. OAE's arise from spontaneous inner ear hair cell and auditory nerve activity and are a well-documented phenomenon in land mammals. In combination with auditory brainstem response (ABR) measures, OAEs can help differentiate central, sensorineural, and conductive losses and both are now common methods for determining ear health in human infants and physically or mentally impaired adults. Human clinical techniques developed in the last five years have significantly reduced test times and enhanced waveform resolutions. ABR techniques have been used with a limited number of captive marine mammals (e.g., work by Ridgway, Supin, Popov, Dolphin, and Møhl) but to date OAE's have not been successful. Further, in all marine studies to date there was no correlated imaging study or other metric of the health of the ear tested. To transition these techniques (cont.)

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Ketten, Darlene R.
Woods Hole Oceanographic Institution

to wild marine mammals requires baseline development of both hardware and analysis techniques. Therefore, under this grant, we proposed to develop the necessary hardware for pool-beachside measures of marine mammal OAE's and ABR's and in animals undergoing rehabilitation to document the stage and progress of ear disease that affected ABR results. In this way, we were able to not only apply the techniques but also to provide a ground-truthing of their sensitivity and accuracy for detecting abnormalities in the hearing of wild marine mammals. During this contract, 1 species of pinniped (*Phoca vitulina*, n=3) and two species of cetacean (*Globicephala melaena*, n=2; *Phocoena phocoena*, n=1) undergoing rehabilitation were tested for ABRs. Because they have a patent external auditory canal, the pinnipeds were also tested for OAEs using a new portable device built with the collaboration of Sonamed, Inc. under the direction of Dr. Dolphin and his assistant, Andrew Quick.

In the pinniped work, three juvenile harbour seals (*Phoca vitulina*) with suspected ear disease were examined with computerized tomography (CT) while undergoing OAE and ABR testing. Because significant disease was found in each of the animals they were retested periodically during their 18 month confinement to treat their infections. Combining CT with OAE and ABR tests allowed simultaneous documentation and quantification of any ear pathology present at the time of the tests as well as a highly accurate method for determining intracanal position of the probe microphone. OAEs were tested bilaterally between 500 Hz and 15 kHz in each seal. Data from the CT and OAE exams were assessed independently. In 2 animals, the CT assessments found middle ears partially occluded with fluid but anatomically normal auditory nerve attenuations and volumes, suggesting a circumscribed infection with no retrograde neuronal loss, consistent with short-term otitis media. OAE tests for these animals found responses at moderately elevated levels, consistent with a diagnosis of conductive hearing loss, while ABR results confirmed normal brainstem functioning, both consistent with the CT findings. In the third animal, no OAEs or ABRs could be obtained with intensities up to 70 dB re 1 μ Pa, suggesting retrograde damage through the brainstem level. CT data for this animal showed inner ear occlusions as well as middle and external ear fibrous formations, consistent with aggressive or longer term disease. In the cetaceans tested, normal waveforms, in comparison to previously published odontocete data, were obtained from all three animals. The work performed under this contract therefore resulted in the following accomplishments: 1) A portable system feasible for use in pool or beach areas with an auxiliary power supply was designed, built, and tested with wild marine mammals; 2) the pinniped test data show that the volume and site of auditory pathologies are strongly correlated with OAE levels, indicating that OAE techniques can be a valuable tool for rapid *in vivo* assessments of pinniped hearing; 3) cetacean ABR data are possible for larger odontocetes and for equivalently sized (i.e., juvenile or smaller mass) baleen whales.