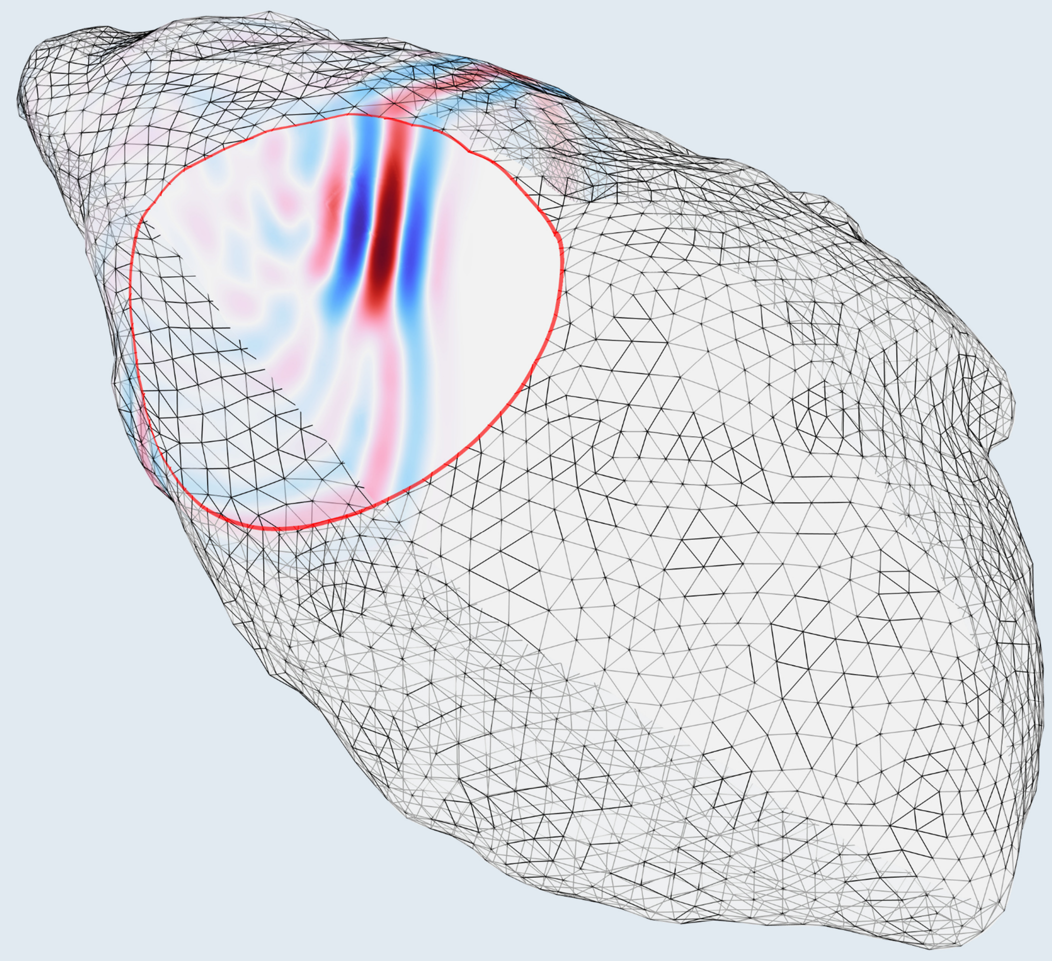

Sound Propagation Through Dolphin Forehead Melon Tissue – "The Acoustic Lens"

3D acoustic model describing the formation of the echolocation beam, based on world unique *in vivo* computer scans of a dolphin.

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Abstract

Toothed whales use echolocation as their primary means of sensing the environment. Air pockets, bone and soft tissues interplay to shape the echolocation beam, but it is still unknown to what extent each contributes to the process. In this study we modelled what effect the specific soft tissue termed "the melon" has on the acoustic propagation of a transient omnidirectional acoustic source using the Acoustics module in the time domain. The model suggests that the melon collimates the acoustic energy into a forward projected echolocation beam. Future studies will focus on adding all tissue types to the model to further illuminate how echolocation beams are formed.

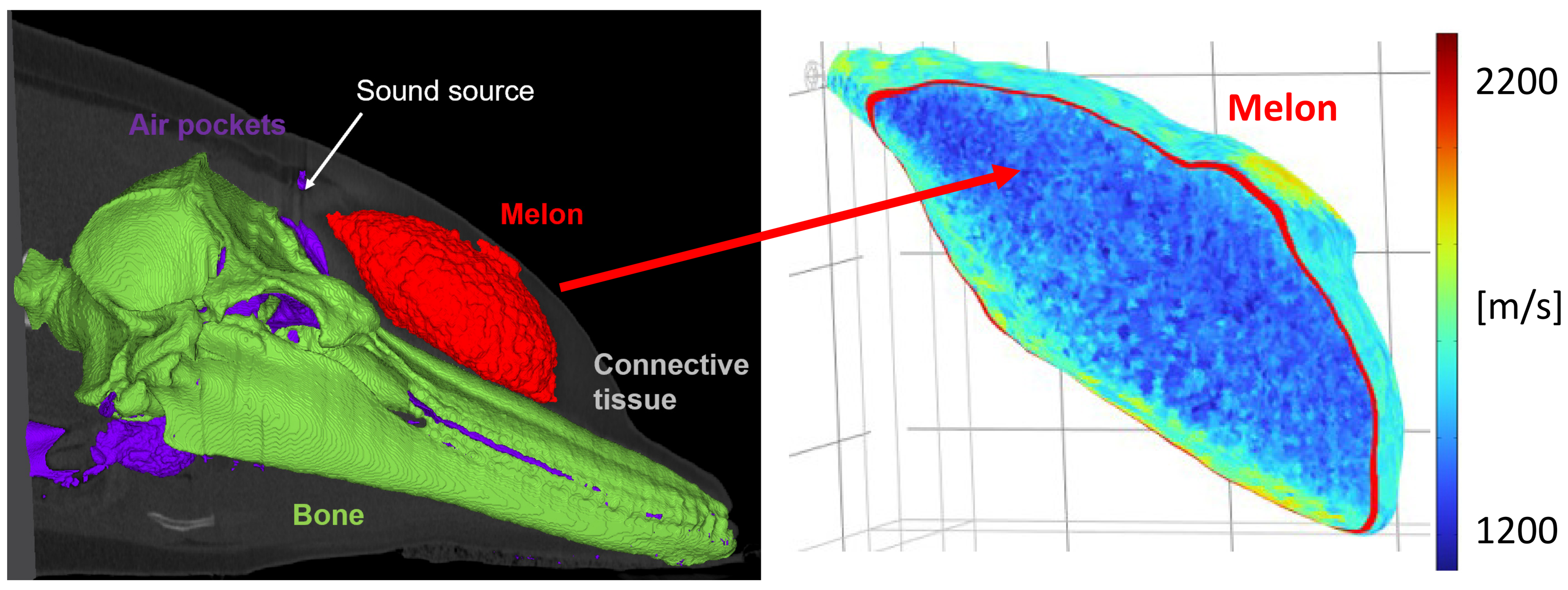

FIGURE 1. Left: CT scans and segmentations of dolphin head tissues. The melon is marked as red. Right: Interpolated material sound velocities inside the core of the melon (cross-section view), based on HU obtained from the CT scans.

Methodology

The melon was segmented from *in vivo* computer tomography (CT) scans of a live dolphin, imported into COMSOL Multiphysics® and placed inside a rectangle of water surrounded by an absorbing layer. Each node in the model was assigned individual material properties (sound velocity and density) derived from linear interpolations of empirical relations [1] to Hounsfield units (HU) obtained from the CT scans. The transient sound source was modelled as a vibrating half-sphere placed on the dorsal side of the most dorsal edge of the melon.

Using the Time Explicit solver based on the discontinuous Galerkin method [2] the model was solved on the computational cluster LUNARC.

Results

The results show the formation of the forward projected echolocation beam 75 µs after onset of the transient sound source located to the left of the sagittal plane of the melon (Figure 2). Our 3D model of sound propagation inside the melon shows that the shape of the melon and the lower sound velocities of the tissue inside the core of the melon, compared to along its edges and to the surrounding water, causes collimation of the acoustic energy in 3D into a forward projected beam. Similar results were achieved with noise added to the CT scans, indicating that the model is not sensitive to small changes in the input parameters.

Future studies will include all tissue types and structural mechanics physics and will model the source as an impulsive tissue closure and nasal air pressure release, which is thought to generate the echolocation transient vibration.

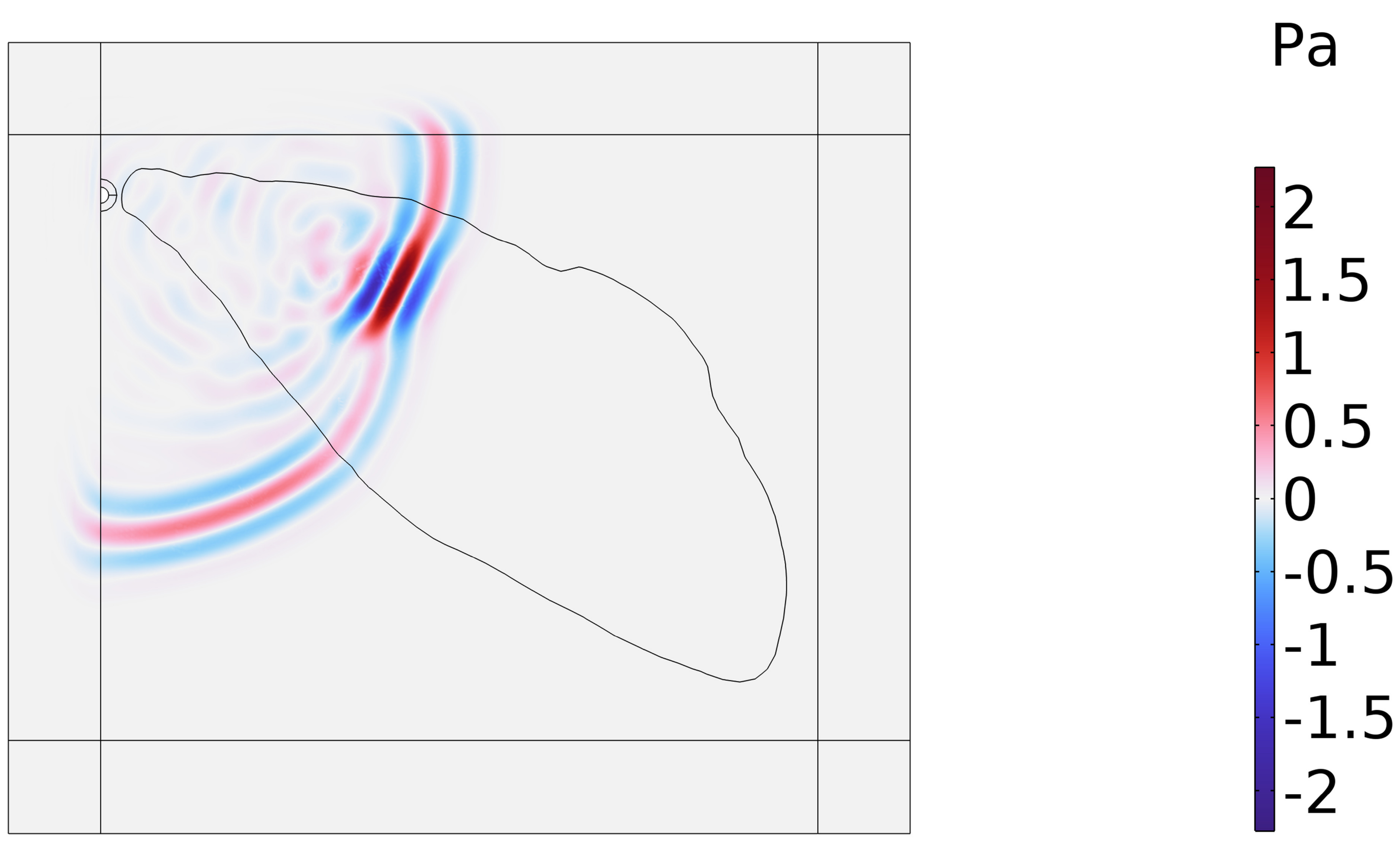

FIGURE 2. The acoustic sound pressure wave front propagated into a forward directed, collimated beam with highest amplitude inside the core of the melon.

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