# Coral Imaging Using Ultrasound

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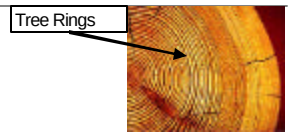
## Abstract

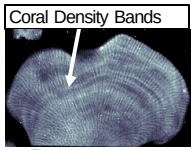
Coral colonies form annual density bands-similar to the growth rings one observes in trees-principally due to seasonal changes in the sea surface temperature. The growth rate of coral, and hence the spatial length scale of the density bands, is about 1-2 cm/year. The long life of some coral species (many centuries) and their abundance across the globe render corals as a valuable archive of climate change.

Currently skeletal density is imaged using x-radiographs on colonies that are removed from the sea floor. A more attractive technique would be to measure corals in situ and we assessed the potential of pulsed ultrasound to image coral density bands. Measurements were carried out using focused 1-MHz transducers, in both reflection- and transmission-mode, to generate parametric images of the reflection coefficient, transmission coefficient, and sound-speed of various coral specimens. The acoustic-based images were compared to x-radiographs and we found that the local sound-speed of the coral correlated very closely with the x-radiographs but reflection and transmission coefficients did not.

Our results suggest that ultrasound can be used to image annual growth bands of coral and it should be feasible to create a portable system that could be used on the sea floor.

## Motivation – Distinguish Year Bands



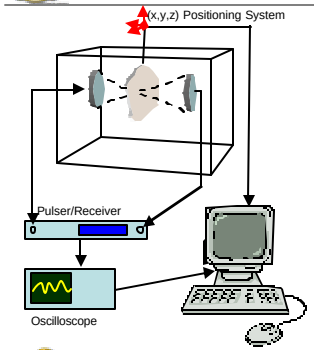

-Skeletal density of coral related to ocean temperature

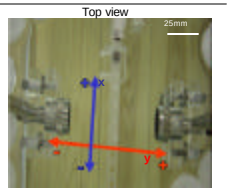
-Currently X-Rays used for imaging

-Ultrasound velocity and attenuation are related to skeletal density

-Ultrasound should be able to detect density bands in coral

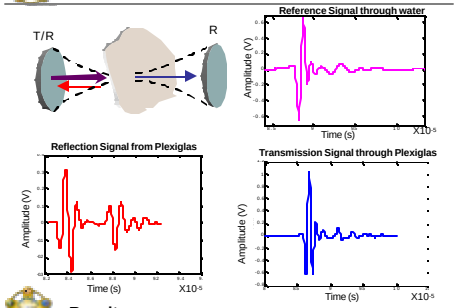
## Setup



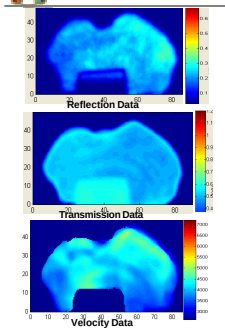



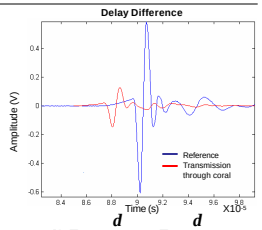

1MHz Focused Transducers

## Technique




## Results



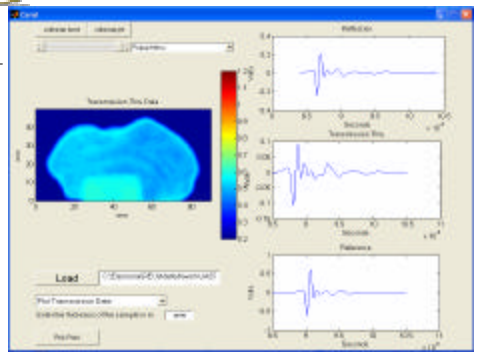




$$v_c = \frac{d}{T_t - T_0 + \frac{d}{v_w}} = \frac{d}{\Delta T + \frac{d}{v_w}}$$

**Where:**
**Vc – velocity of sound in coral**
**Vw – velocity of sound in water (1500m/s)**
**d – thickness of coral**
**?T – difference between the reference and transmission delay**

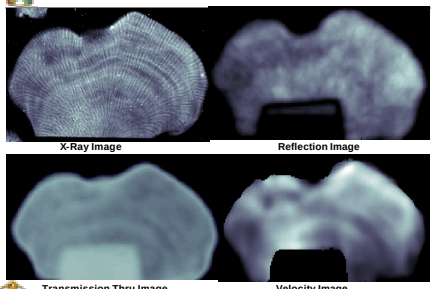
Reflection and transmission images: the maximum of the first peak of the signal was plotted.
Velocity image: value from the above formula was plotted.

## GUI

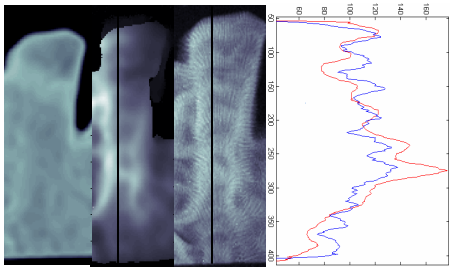


In order to make the data processing easier and faster a graphical user interface (GUI) was developed using MATLAB.

## Results – JA25




## Results – JA27




## Conclusion

- **Ultrasound can be used to image annual growth bands of coral**
- **It should be feasible to create a portable system that could be used on the sea floor.**

## References

1. R. O. Cleveland, A. L. Cohen, R. A. Roy, H. Singh, T. L. Szabo,"Imaging Coral II: Advances in Imaging of Coral Skeleton Using Ultrasound," *Subsurface Sensing Technologies and Applications 5:43-61 (2004)*
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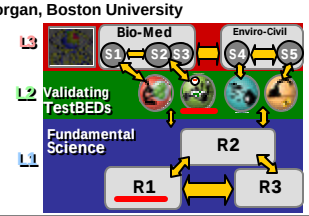


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