Broadband acoustic scattering from nonlinear internal waves

Andone C. Lavery
Woods Hole Oceanographic Institution

Presented by
Timothy K. Stanton
Woods Hole Oceanographic Institution

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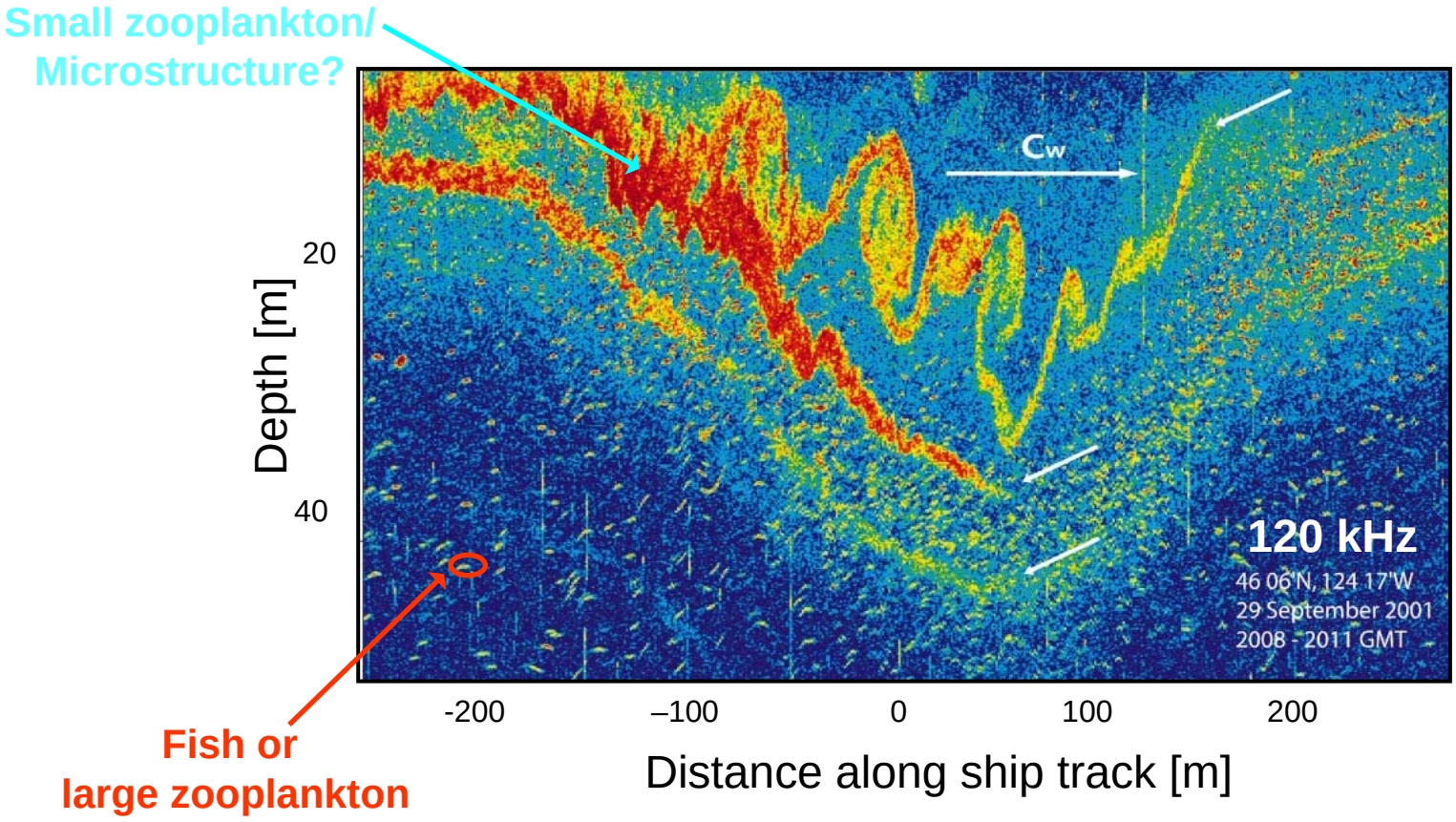
Why use acoustic scattering techniques for investigating physical processes?

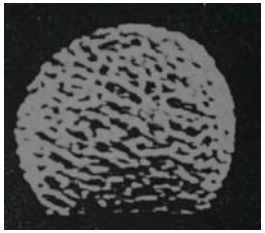


Moum *et. al*., *J. Phys. Oceanography* **33**, 2093-2112, 2003.

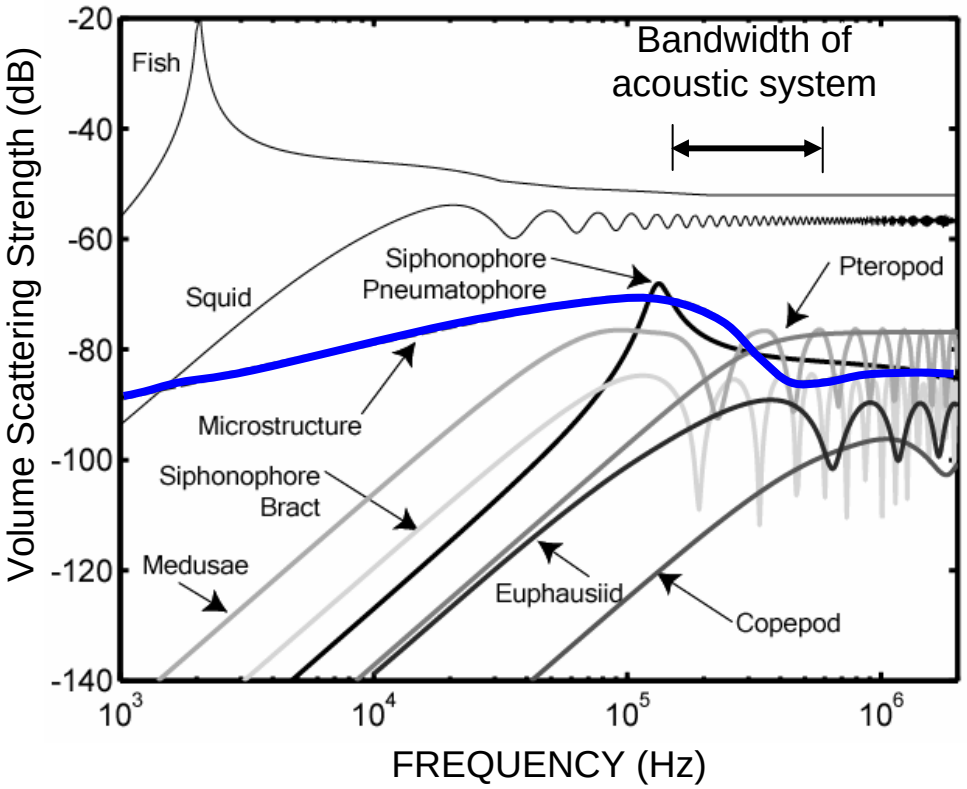
Sources of scattering and scattering models

Fish
(Gas-bearing)

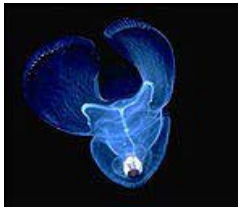
Squid (Fluid-like?)



Turbulent Microstructure



Siphonophores
(Gas-bearing)



Pteropods
(Elastic-shelled)

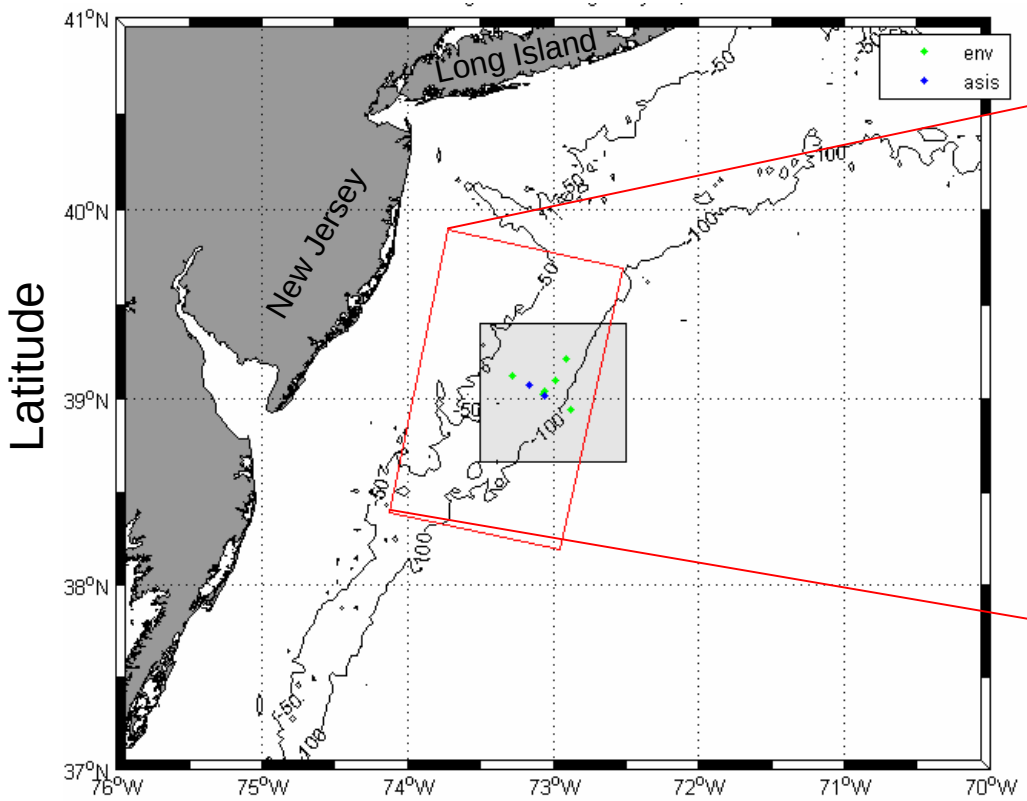
Copepods
(Fluid-like)

Medusae
(Fluid-like)

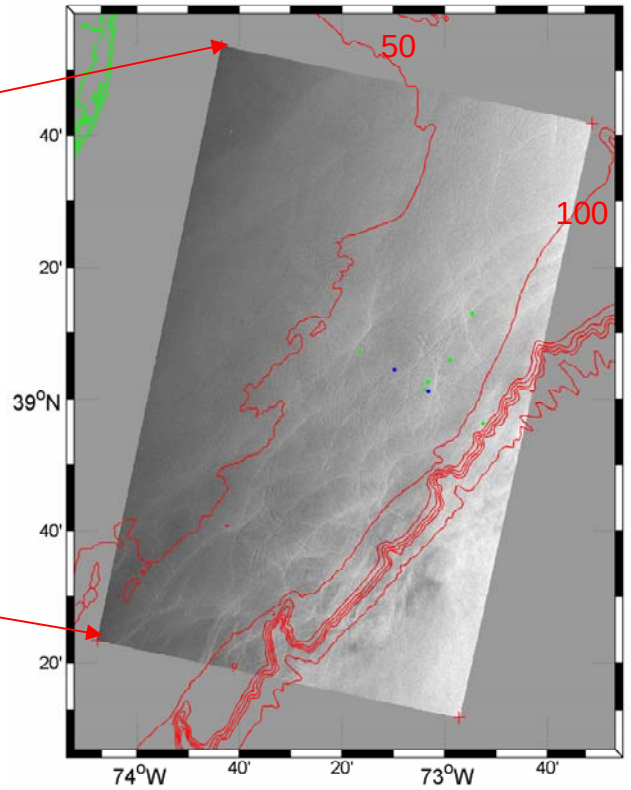
Euphausiids
(Fluid-like)

SW06/NLIWI Experiment

Experiment duration:
July 31- August 27, 2006



SARS Satellite Image
July 23, 2006



Complex IW field

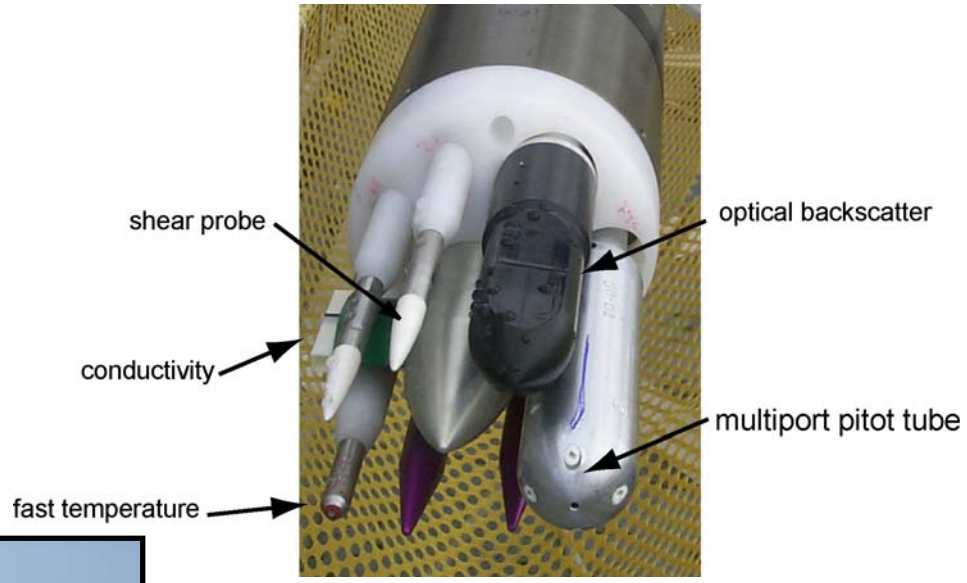
Broadband acoustic backscattering system

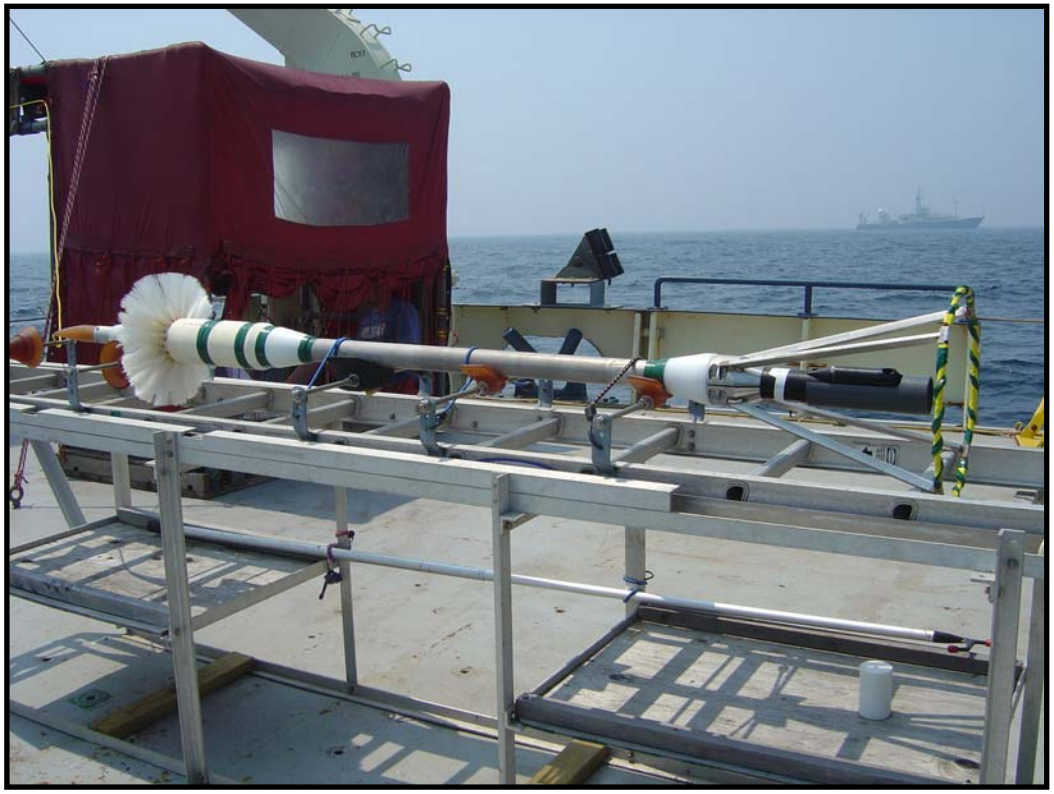
Vertical Down-Looking

Horizontal Side-Looking

4 Broadband Transducers:
160 – 270 kHz, 10^{o} (3dB-BW)
220 – 330 kHz , 8^{o} (3dB-BW)
340 – 470 kHz ,12^{o} (3dB-BW)
450 – 600 kHz , 9^{o} (3dB-BW)

Microstructure measurements (Jim Moum)

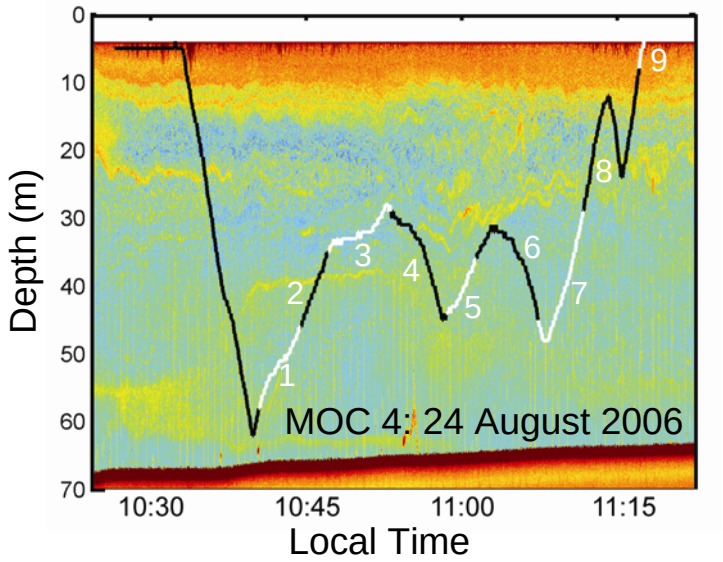




Zooplankton net tows

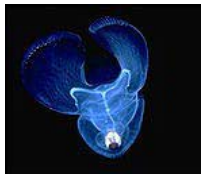
MOCNESS:
Multiple Opening/Closing Net and Environmental Sampling System

MOCNESS track superimposed on 120 kHz echogram

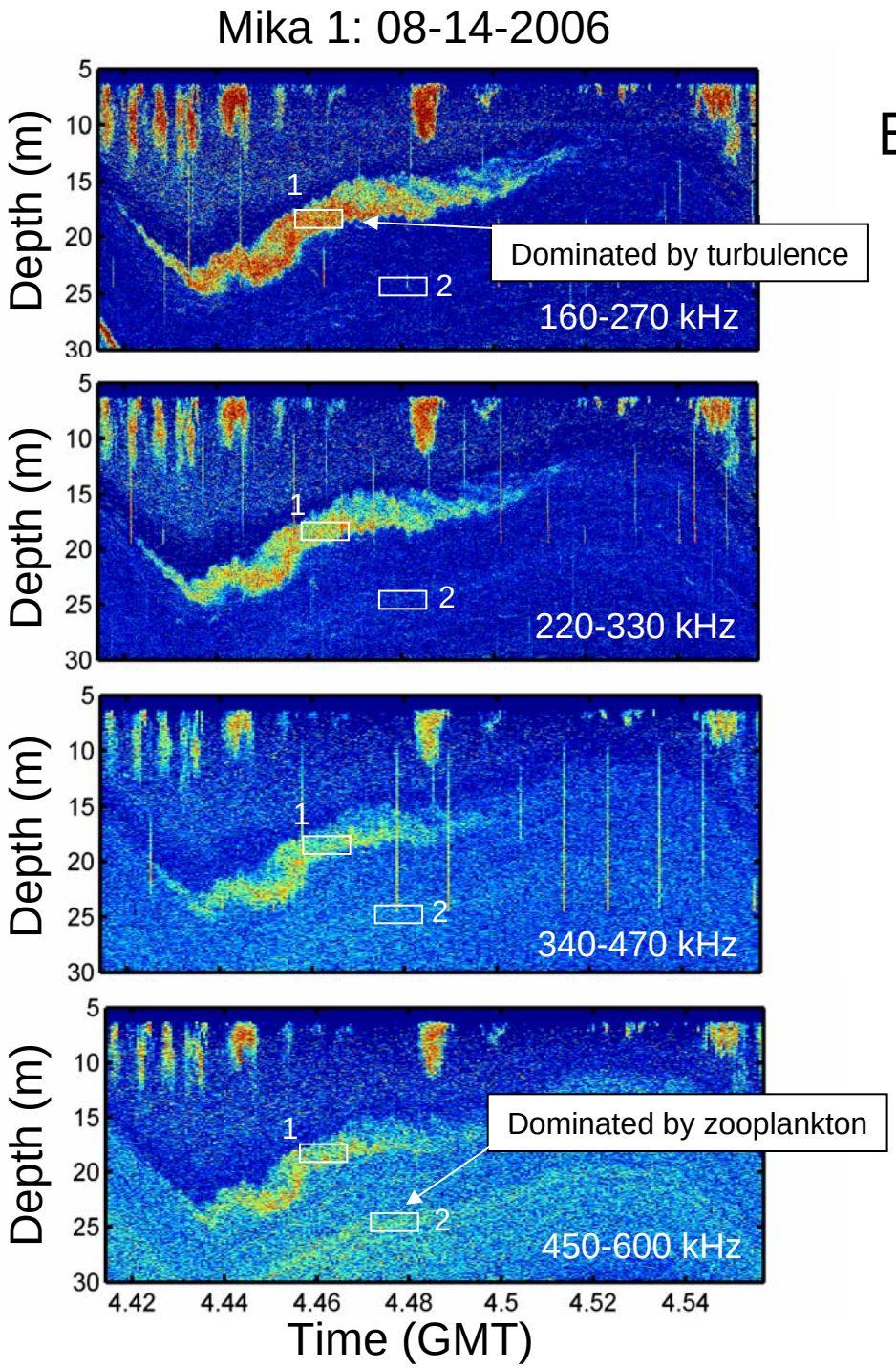


Conclusions:

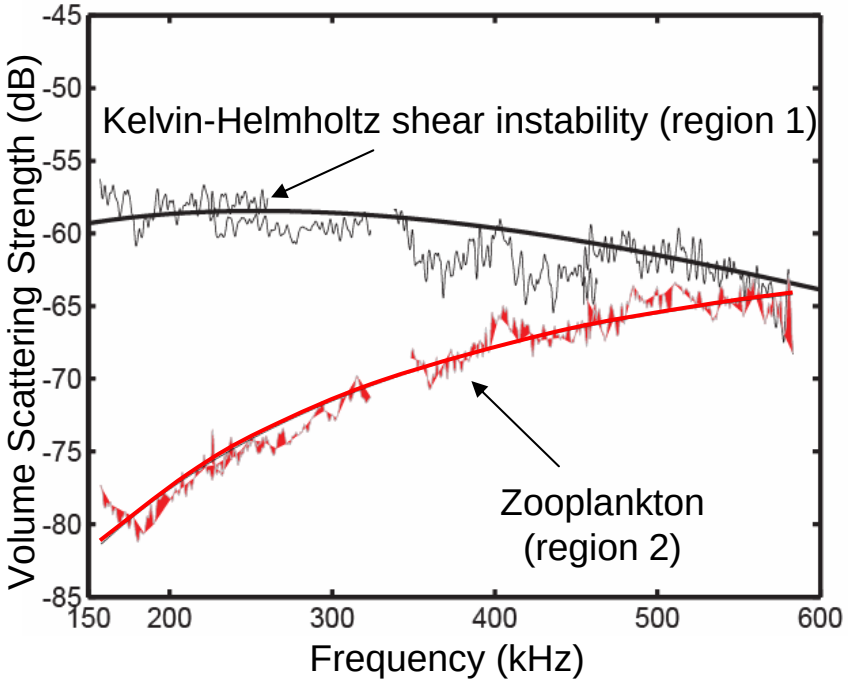
1. Abundance and biomass dominated by small copepods (fluid-like)
2. Scattering dominated by small pteropods (elastic-shelled) and amphipods (fluid-like)



Broadband spectra: example 1

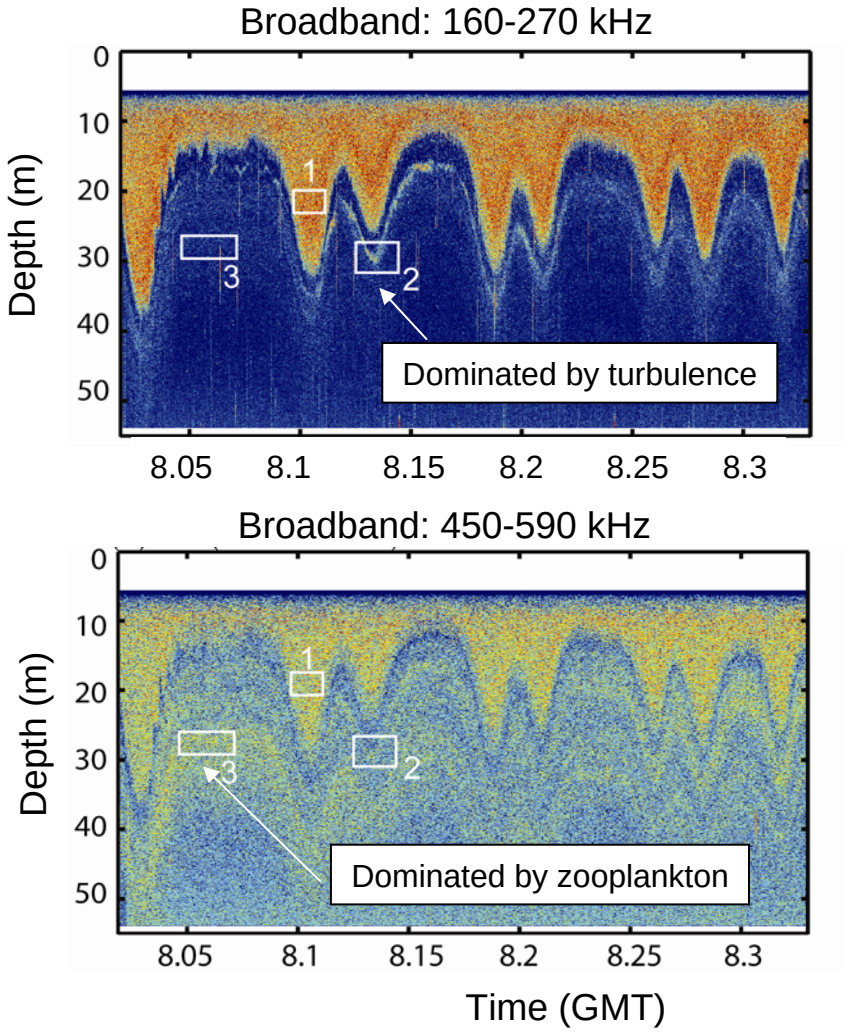


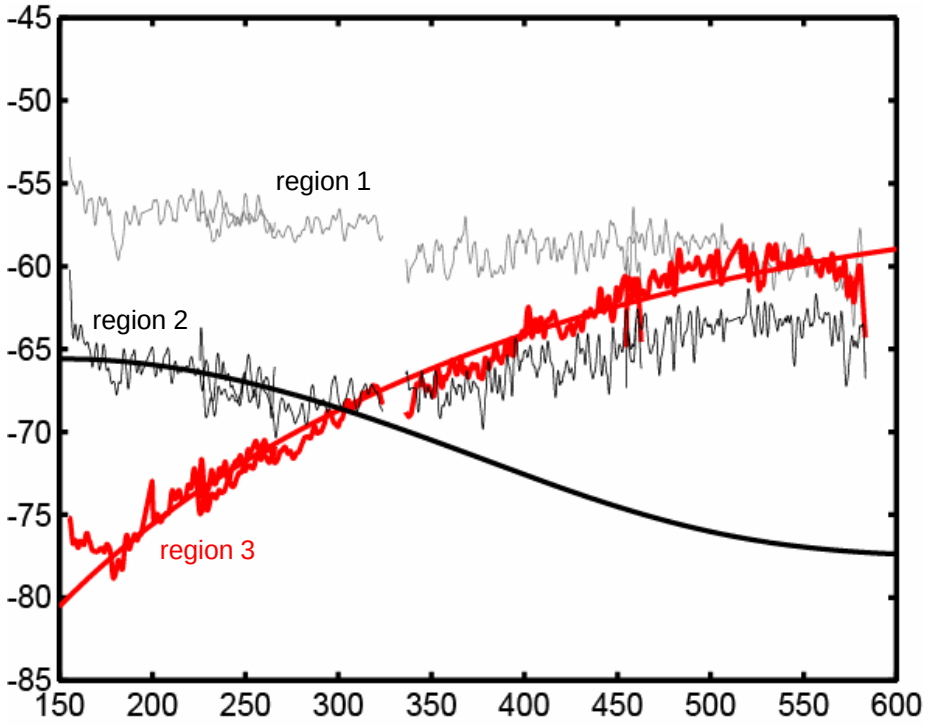
Region 1: Microstructure dominated.
Inferred dissipation: $\varepsilon = 8 \times 10^{-6}$ W/kg.



Region 2: Zooplankton dominated.
Inferred pteropod: diameter = 0.78 mm.

Broadband spectra: example 2





Region 2: MIXED:

- Microstructure dominated at low frequencies.
  Inferred dissipation: $\varepsilon = 2.5 \times 10^{-6}$ W/kg.
- Zooplankton dominated at high frequencies.

Region 3: Zooplankton dominated at all frequencies.
Inferred: 960 pteropods/m^3 of diameter 0.53 mm.

Summary/Conclusions

- First use of broadband acoustics to image microstructure.
  - Improved image resolution.
  - Improved discrimination from zooplankton.

- Scattered spectra often consistent with scattering from biology alone, particularly at depths below the thermocline.

- Scattered spectra consistent with scattering from turbulent oceanic microstructure alone only at a few locations, particularly in the vicinity of shear instabilities.